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IN THIS ISSUE:

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ARTICLES

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The Educational Audiology Association (EAA) is an international professional organization for audiologists who specialize in the management of hearing and hearing impairment within the educational environment. EAA was established in 1984 to advocate for educational audiologists and the students they serve. The American Academy of Audiology (AAA) and the American Speech-Language-Hearing Association (ASHA) recognize EAA as a related professional organization (RPO), which facilitates direct communication and provides a forum for EAA issues between EAA, AAA, ASHA, and other RPOs. Through the efforts of the EAA executive board and individual members, the association responds to issues and concerns which shape our profession.

> **EAA Mission Statement:**
> *The Educational Audiology Association is an international organization of audiologists and related professionals who deliver a full spectrum of hearing services to all children, particularly those in educational settings.*
>
> *The mission of the Educational Audiology Association is to act as the primary resource and as an active advocate for its members through its publications and products, continuing educational activities, networking opportunities, and other professional endeavors.*

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700 McKnight Park Drive, Suite 708, Pittsburgh, PA 15237
Phone: 800-460-7EAA (7322) ● Fax: 888-729-3489
www.edaud.org ● admin@edaud.org

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Acceptable Noise Levels and Speech Perception in Noise for Children With Normal Hearing and Hearing Loss

Alisha L. Jones
Auburn University
Auburn, Alabama

Robert E. Moore
University of South Alabama
Mobile, Alabama

The purpose of this study was to evaluate acceptable noise levels in children with and without hearing loss as well as to explore a relationship between acceptable noise levels and speech understanding in noise in children. A between subjects design was used. Sixteen children with normal hearing served as the control group and sixteen children with hearing loss served as the experimental group. Results indicated no significant differences for acceptable noise levels between children with normal hearing and children with hearing loss. No significant relationship was found between acceptable noise levels and speech reception threshold for sentences in children with and without hearing loss. The results of the present study are consistent with results found in previous adult acceptable noise level studies. Overall, results suggest that acceptable noise levels in children with normal hearing and in children with hearing loss are similar to acceptable noise levels in adults with normal hearing and in adults with hearing loss.

INTRODUCTION

Noise can negatively affect the ability to detect critical aspects of speech in both adults and children. The ability to understand speech accurately in the presence of noise is critical for children in light of learning educational skills and speech and language development (Mowrer, 1958). Background noise, resulting in a poor signal to noise ratio (SNR), can impede an individual's ability to hear speech, regardless of age and/or hearing status. Children, regardless of hearing status, tend to perform poorer on speech in noise tasks, compared with adults (Papso & Blood, 1989; Nittrouer & Boothroyd, 1990; Johnson et al., 1997; Fallon et al., 2000; Johnson, 2000; Fallon et al., 2002; Hall et al., 2002; Wightman & Kistler, 2005; Nishi et al., 2010; Corbin et al., 2016). The ability to understand speech in noise is affected by maturation variables (e.g. life experience, vocabulary, neurologic immaturity, etc.) (Flexer, 2005). Studies have found that younger children perform poorer on speech in noise tasks than older children (Elliott, 1979; Fallon et al., 2000; Johnson, 2000; Fallon et al., 2002; Jamison et al., 2004; Neuman et al., 2010; Corbin et al., 2016). It appears that a child's ability to perform some speech in noise tasks reaches adult performance levels by age 14 years (Johnson, 2000; Corbin et al., 2016).

Acceptable noise levels (ANLs) are a possible alternative way to measure the effects of noise on children. ANLs, first studied by Nabelek et al. (1991), are used to measure an individual's acceptance of noise while listening to speech. ANLs are calculated by obtaining the listener's most comfortable listening (MCL) level minus the background noise level (BNL). BNL is defined as the highest level of background noise deemed acceptable while listening to speech discourse. ANL research has suggested that low ANLs (< 7 dB) indicate greater acceptance of noise; therefore, these individuals are predicted to have greater success with hearing aids. Likewise, high ANLs (> 12 dB) indicate lower acceptance of noise; thus, individuals with high ANLs are predicted to have less success with hearing aids (Nabelek, et al., 2006). Previous research has generally found that age, hearing sensitivity (pure-tone average [PTA]), gender, locus of control, background noise, acoustic reflex thresholds, contralateral suppression of otoacoustic emissions, reverberation, and speech understanding are not related to the measure of ANL (Nabelek et al., 1991; Rogers et al., 2003; Nabelek et al., 2004; Harkrider & Smith, 2005; Freyaldenhoven & Smiley, 2006; Nabelek et al., 2006; von Hapsburg & Bahng, 2006; Freyaldenhoven et al., 2007; Plyler et al., 2007; Gordon-Hickey & Moore, 2007; Plyler et al., 2008; Johnson, et al., 2009). ANL has been found to be variable, normally distributed, reliable over time, and can predict hearing aid success with about 85% accuracy (Nabelek et al., 1991; Nabelek et al., 2004; Nabelek et al., 2006; Plyler et al., 2007). Variables that contribute to a person's ANL are low-frequency hearing thresholds (the better the low-frequency thresholds, the higher the ANL), personality traits (the more openness a person exhibits, the lower the ANL; the more conscientious a person exhibits, the higher the ANL), self-control (the higher the self-control, the lower the ANL), speech presentation level (the lower the speech presentation level, the lower the ANL), and speech intelligibility (used as a cue to set ANL) (Franklin et al., 2006; Freyaldenhoven et al., 2007; Nichols & Gordon-Hickey, 2012; Recker & Edwards, 2013; Brännström & Olsen, 2017; Recker & Micheyl, 2017).

The first research study to examine ANLs in children was reported by Freyaldenhoven and Smiley (2006). They measured ANLs for thirty-two normal hearing children (sixteen 8 year olds and sixteen 12 year olds). The purpose of the study was to demonstrate that ANLs could be reliably obtained in younger children with child-friendly instructions. The results showed that these age groups could provide reliable ANLs in 2 to 4 minutes, similar to test time for adults, and the ANLs were normally distributed in these age groups. Freyaldenhoven and Smiley (2006) found that ANLs for this group of participants were not related to type of noise, gender, or age of the child and indicated that ANL results for children with normal hearing were similar to those found in adults; however, no statistical analyses were conducted to examine the similarities between the ANL results for children and adults.

Moore et al. (2011) compared ANLs in thirty-four children (ages 8 to 10 years) and thirty-four young adults (ages of 19 and

29 years) with normal hearing. Significant main effects were found between groups for MCL and BNL measures, but not for ANL. Further analysis revealed that MCL and BNL measures were significantly lower in children than adults. Statistical analyses of the ANL results for the two populations found that there was no significant difference in ANLs between children and adults. Moore et al. (2011) concluded that ANLs may not change from childhood to adulthood. The significant differences between MCL and BNL measures suggest a developmental change occurs from childhood to adulthood, but ANLs remain the same. ANL may not be related to age; therefore, maturation variables in the auditory system, which change over time, do not affect the variance of ANL.

Previous studies did not compare ANL results in children with normal hearing with ANLs in children with hearing loss (Freyaldenhoven & Smiley, 2006; Moore et al., 2011). Also, a comparison of ANLs and speech perception in noise results has not been reported in children. While most ANL studies in adults did not find a significant relationship between the presence of hearing loss or speech perception ability and ANL (Nabelek, et al., 2004; Nabelek et al., 2006; von Hapsburg & Bahng, 2006; Plyler, et al., 2008), Ahlstrom, et al. (2009) found a positive correlation between unaided Hearing in Noise Test (HINT) sentence thresholds and unaided ANL scores with speech babble presented at 0 degree azimuth. Ahlstrom, et al. (2009) also found positive correlations between aided HINT sentences with spatial benefit and aided ANLs with spatial benefit. It has been documented that children need higher SNRs to understand speech in noise (Papso & Blood, 1989; Nittrouer & Boothroyd, 1990; Johnson, et al., 1997; Fallon et al., 2000; Johnson, 2000; Fallon et al., 2002; Hall et al., 2002; Wightman & Kistler, 2005; Nishi et al., 2010; Corbin et al., 2016). Consequently, children may accept less noise on an ANL task in order to achieve higher SNRs.

The purpose of the present study was to assess ANLs in children with hearing loss to study the possible usefulness of ANL in the pre-fitting hearing aid evaluation of pediatric patients. While the authors recognize there are many different variables that contribute to the successful use of hearing aids in the pediatric population, there is very little published research on these factors. This project is the first step to identify if ANLs are viable option in the pediatric population with hearing loss. It was hypothesized that ANLs would not be significantly different between the two groups of children. Additionally, the relationship between ANLs and speech perception in children were evaluated since there are significant differences in performances on speech perception tasks between the pediatric and adults populations. It was hypothesized that there would be a significant relationship between ANL and speech perception with higher SNRs being related to higher ANL scores. Lastly, the test-retest reliability and normality of ANLs in the both pediatric populations were examined. These two factors were evaluated to determine if ANLs could be reliably determined as well as normally distributed in children with and without hearing loss. It was hypothesized that ANLs would be able to be reliably determined in this population and that ANLs would be normally distributed following the same pattern that ANLs do in the adult population. While the present study does reproduce and corroborate research conducted in the adult population literature, it adds data from the pediatric population to which there are very few published studies.

METHOD

Participants

Thirty-two children, ages of 6-12 years, served as participants. Sixteen participants had normal hearing with hearing threshold levels 10 dB HL or better (ANSI S3-6-1996). Participants with hearing thresholds equal to or less than 10 dB HL at 500Hz, 1000 Hz, 2000 Hz, and 4000 Hz were included in the normal hearing group. Mean hearing thresholds for the children with normal hearing are shown in Figure 1. Range, mean, and standard deviations of all thresholds are shown in Table 1. Sixteen participants had bilateral hearing impairment with unaided hearing thresholds greater than 25 dB HL (ANSI S3.6-1996). Mean unaided thresholds for the children with hearing loss are shown in Figure 2. Range, mean, and standard deviations of all thresholds are shown in Table 1. The participants with hearing loss wore binaural hearing aids with mean length of use of 4 years (SD = 3 years). The mean age for the participants with normal hearing was 9 years and 8 months (SD = 1 year and 9 months). Participants for the normal hearing group ranged in age from 6 years and 11 months to 12 years and 9 months. The mean age for the participants with hearing impairment was 10 years and 2 months (SD = 1 year and 8 months). Participants for the hearing impaired group ranged in age from 7 years and 3 months to 12 years and 7 months. All participants were approximately equally distributed across the age range. Parents or guardians provided case history information. There was no history of tinnitus, active middle ear disorders, neurologic disorders, or use of central nervous system (CNS) stimulant medications for all participants. Participants read and signed a Statement Assent approved by the Internal Review Board at the University of South Alabama. If a participant was too young to read independently the Statement of Assent, the document was read to them. The parent or guardian of each child read and signed the Statement of Consent for their child's participation in the study.

Apparatus and Test Materials

Audiometric testing, ANL tasks, and Hearing in Noise test – Children (HINT-C) tasks were completed in a sound treated booth that met the American National Standards Institute (ANSI) guidelines for permissible ambient noise (ANSI S3. 1-1999). Audiometric testing was performed using an audiometer (Grason-Stadler Instruments GSI-61) calibrated in accordance with the ANSI (1996) specifications for a Type 2 audiometer. Pure tones were presented through TDH 50P earphones.

The primary stimulus for all ANL tasks was running discourse by a recorded male voice (Arizona Travelogue, Comos Distributing) used in previous ANL studies (i.e., Nabelek et al., 2004; Freyaldenhoven et al., 2005a; Freyaldenhoven et al., 2005b; Franklin, et al., 2006; Nabelek et al., 2006; Gordon-Hickey and Moore, 2007). The background noise was the twelve-talker babble from the R-SPIN test (Bilger, et al., 1984). The background noise used within the HINT Pro 7.2 Audiometric System was filtered white noise. Testing for both ANL and HINT-C was conducted using a loudspeaker placed at zero degree azimuth (both speech and noise) relative to the participant, and the participant was seated one meter away from the loud speaker. Stimuli for the ANL tasks were delivered via a Sony compact disc player (Model CDP-CD345) through the audiometer to the loudspeaker. Stimuli for the HINT-C (Nilsson et al., 1996) were presented through the HINT Pro 7.2 Audiometric System to the loudspeaker.

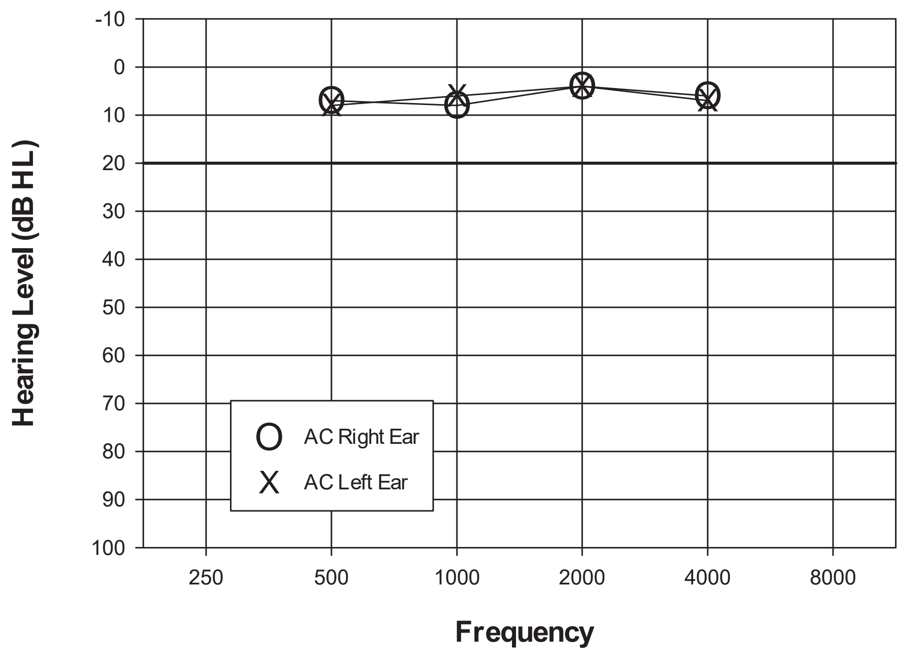


Figure 1. Mean threshold levels (dB HL) for 16 participants with normal hearing.

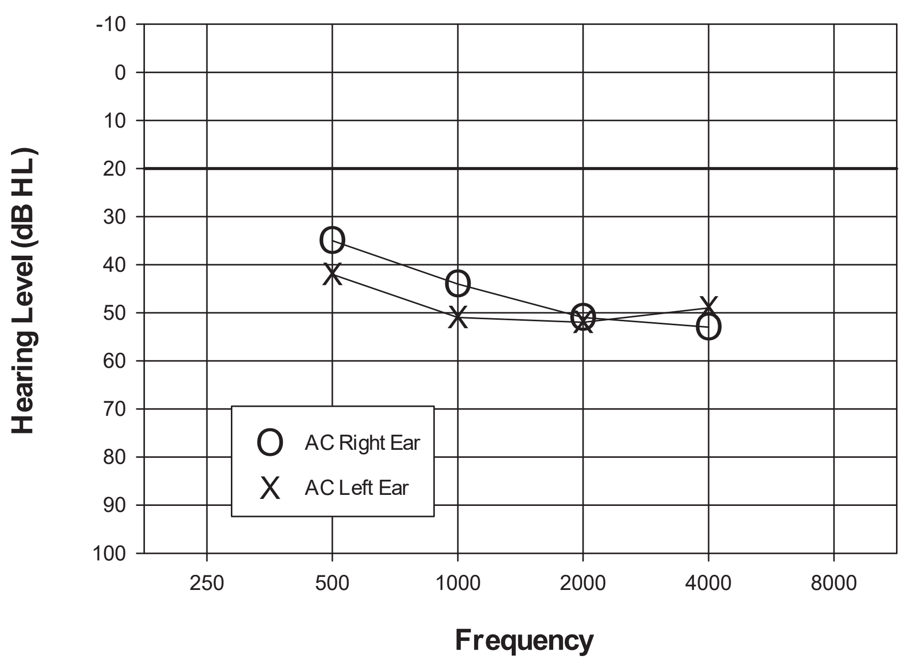


Figure 2. Mean unaided threshold levels (dB HL) for 16 participants with hearing loss.

Table 1. Range, mean, and standard deviation of hearing thresholds for participants with normal hearing and for participants with hearing loss.

	Participants with Normal Hearing			Participants with Hearing Loss		
Frequency	Range	Mean	Standard Deviation	Range	Mean	Standard Deviation
500 Hz Right Ear	10	7	4	55	35	18
500 Hz Left Ear	5	8	3	95	42	23
1000 Hz Right Ear	5	8	3	60	44	19
1000 Hz Left Ear	10	6	3	60	51	17
2000 Hz Right Ear	10	4	4	80	51	20
2000 Hz Left Ear	10	4	3	70	52	20
4000 Hz Right Ear	10	6	4	75	53	24
4000 Hz Left Ear	10	7	4	80	49	24
PTA Right Ear	8	7	3	52	44	17
PTA Left Ear	8	6	3	67	48	18

* All numbers are in dBHL.

** PTA=Pure tone average using 500Hz, 1000Hz, 2000Hz, and 4000Hz.

Procedures

All testing was completed in one 90-minute session with rest breaks provided as needed. The session included obtaining consent from the child and parent or guardian, obtaining a case history, audiometric testing, and completing two experimental tasks (speech perception testing using the HINT-C and ANL). The experimental tasks were counterbalanced. All experimental tasks were completed unaided for the participants with hearing loss.

ANL procedures for this study were similar to those used in previous ANL studies with children (Freyaldenhoven and Smiley, 2006; Moore et al., 2011) using modified instructions with appropriate vocabulary and language for children. The Appendix A shows the modified ANL instructions. Measures of MCL and BNL were obtained in order to calculate ANL. Participants were instructed to make intensity adjustments of the primary stimulus and background noise by using thumbs-up, thumbs-down, and flat palm signals. The thumbs-up signal was used to signal an increase in the intensity, thumbs-down to signal a decrease in the intensity, and flat palm to stop adjustments. This procedure was demonstrated to the participants. If a participant had any difficulty with this task, the testing was halted and the participant was reinstructed to ensure understanding of the task.

MCL was the intensity level at which the participant preferred to listen to the primary stimulus. In order to obtain MCL for each participant, the primary stimulus was presented at 30 dB HL and the level of the stimulus was adjusted in 5 dB steps, based on the participants hand signals described above. The participant was instructed to adjust the level of the story up “until the story is louder than you would want to listen to on the radio.” Then the participant was instructed to adjust the level of the story down “until the story is softer than you would want to listen to on the radio.” Finally, the participant was instructed to adjust the level of the story up and down to “where you would want to listen to the story on the radio.” During this final adjustment, the level was adjusted in 2 dB steps. Once the participant was satisfied with the level of the stimulus, the tester recorded the intensity of the speech stimulus as the participant’s MCL. MCL was measured three times, and the results were averaged.

BNL was the highest level of background noise acceptable to the participant while listening to speech. In order to measure BNL, the primary stimulus was presented at the participant’s averaged MCL, and the secondary stimulus was presented as background noise. The secondary stimulus was introduced at 30 dB HL and adjusted in 5 dB steps, based on the hand signals previously described. The participant was instructed to increase the level of the background noise to a level where the story could not be heard clearly. Then the participant was instructed to decrease the level of the background noise to a level where the story could be heard very clearly. Finally, the participant was instructed to adjust the level of the background noise up or down “to the most noise that you would be willing to listen to and still be able to listen to the story for a long time.” During the final adjustment, the level was adjusted in 2 dB steps. Once the participant was satisfied with the level, the tester recorded the intensity as the BNL. BNL was measured three times and the results were averaged. ANL was the difference value between average MCL and average BNL (ANL = MCL-BNL).

For the HINT-C, sentences were presented in quiet and noise conditions. The participants completed a practice list in quiet, completed one test list in quiet to obtain the HINT threshold, and then completed three lists in the noise condition. Each list contained 10 sentences. The level of the speech was presented at 65 dBA with the noise presented at the recommended 65 dBA for the initial sentence. The participant was instructed to repeat the entire sentence as presented. If the participant correctly repeated the sentence, then the level of the speech was decreased 4 dB. If the participant could not correctly repeat the sentence, the level of the speech was increased 4 dB. After the first four sentences, the same procedure was followed for the remaining sentences by increasing or decreasing the speech in 2 dB steps, depending upon correct or incorrect repetitions of the entire sentence. The results of the two best reception thresholds for sentences (RTS) were averaged and recorded as a dB threshold for signal-to-noise (S/N), based on the protocol recommended by Nilsson et al. (1996).

RESULTS

Test-Retest Reliability Analysis

The test-retest reliability of each measure was analyzed to ensure consistency. The mean MCL, mean BNL, ANL, mean RTS in quiet, and RTS in noise for each participant are displayed in Tables 2 and 3. MCLs and BNLs were measured three times and averaged for each participant. The average BNL was subtracted from the average MCL to calculate ANL for each participant. Overall reliability of the three MCL and BNL measurements for the group with normal hearing and the group with hearing loss (unaided) were evaluated with Pearson product-moment correlations. All correlation coefficients were significant ($p < 0.01$); r-values for MCL ranged from 0.943 to 0.992; and r-values for BNL ranged from 0.953 to 0.990, indicating strong reliability of both measures (see Table 4). Overall reliability of the two best RTS in noise measurements for the participants with normal hearing and the participants with hearing loss (unaided) were evaluated with Pearson product-moment correlations. The correlation coefficients were significant ($p < 0.01$) and r-values ranged from 0.821 to 0.903, which indicated strong reliability (see Table 4).

Statistical Analysis of ANL and Speech Perception

To test the hypothesis that there would not be significant group differences measured for participants with normal hearing and participants with hearing loss, a one-way multivariate analysis of variance (MANOVA) was conducted. Significant group differences were found (Wilks's $\Lambda = .31$, $F [5, 26] = 11.36$, $p < 0.01$, $\eta2 = .70$). Analyses of variances (ANOVA) were conducted for MCL, BNL, ANL, RTS in quiet, and RTS in noise. The Holm-Bonferroni method was used to control for familywise error rates. Results showed significant group differences for MCLs ($F [1, 30] = 6.45$, $p = 0.02$, $\eta2 = .18$) and for BNLs ($F [1, 30] = 10.59$, $p < 0.01$, $\eta2 = .26$). MCLs and BNLs were significantly higher for the participants with hearing loss. Results showed no significant group differences for ANLs ($F [1, 30] = 0.56$ $p = 0.50$, $\eta2 = .02$). Results showed significant group differences for RTS in quiet ($F [1, 30] = 65.45$, $p < 0.01$, $\eta2 = .69$), and for RTS in noise ($F [1, 30] =33.93$, $p < 0.01$, $\eta2 = .53$). Participants with hearing loss had higher thresholds in quiet, and required higher SNRs in noise than the participants with normal hearing. Figures 3 and 4 show the results from above.

Correlation Analysis

It was hypothesized that there would be a significant relationship found between ANLs and RTS in noise, and a Pearson product-moment correlation was conducted between ANLs and RTS in noise in each group. No significant relationship was found between ANLs and RTS in noise for children with normal hearing ($r = 0.20$, $p = 0.46$) or children with hearing loss ($r = -0.07$, $p = 0.79$). Pearson product-moment correlations were also conducted to assess a possible relationship between ANLs and pure tone averages (PTAs). No significant relationship was found between ANL and the PTA for each ear for the participants with normal hearing (Right Ear: $r = -0.06$, $p =$

Table 2. Mean MCLs, mean BNLs, ANLs, RTS in quiet, and RTS in noise for participants with normal hearing.

Participant Number	Mean MCL (dB HL)	Mean BNL (dB HL)	ANL (dB)	RTS in Quiet (dBA)	RTS in Noise (dB S/N)
1	53	51	2	37.0	-0.7
2	61	48	13	26.6	-1.4
3	46	47	-1	30.0	-0.2
4	64	53	11	27.6	1.0
5	45	47	-2	26.2	-1.9
6	53	49	4	21.0	-0.7
7	54	44	10	27.7	-1.6
8	42	26	16	14.8	-2.4
9	55	47	8	18.2	-2.4
10	45	43	2	22.5	-1.2
11	54	45	9	22.6	-0.2
12	79	73	6	22.9	-1.2
13	45	46	-1	20.1	-2.3
14	54	48	6	16.3	-2.7
15	51	39	12	16.1	2.2
16	57	37	20	15.9	-0.6
Mean (S.D.*)	53.63 (9.11)	46.44 (9.54)	7.19 (6.38)	22.84 (6.09)	-1.02 (1.31)

*S.D. = Standard Deviation

Table 3. Unaided mean MCLs, mean BNLs, ANLs, RTS in quiet, and RTS in noise for participants with hearing loss.

Participant Number	Mean MCL (dB HL)	Mean BNL (dB HL)	ANL (dB)	RTS in Quiet (dBA)	RTS in Noise (dB S/N)
17	65	52	13	67.1	5.0
18	57	47	10	51.4	3.2
19	67	63	4	63.9	5.8
20	54	47	7	40.7	-0.2
21	76	69	7	60.7	4.3
22	49	51	-2	40.2	1.6
23	65	39	26	29.8	0.2
24	54	54	0	39.7	-0.5
25	85	71	14	55.1	2.0
26	59	61	-2	56.5	1.8
27	59	59	2	67.4	4.4
28	42	47	-5	33.1	1.6
29	81	74	7	43.5	3.2
30	61	67	-6	57.5	3.0
31	68	61	7	73.0	8.4
32	63	61	2	68.4	7.4
Mean (S.D.*)	62.81 (11.24)	57.69 (10.01)	5.25 (8.12)	53.00 (13.61)	3.95 (2.63)

*S.D. = Standard Deviation

Table 4. MCL, BNL, and RTS in noise measurement correlation coefficients (r) for the participants with normal hearing and hearing loss (unaided).

Measures	Normal Hearing	Hearing Loss-Unaided
MCL1 and MCL2	r = 0.965	r = 0.992
MCL1 and MCL 3	r = 0.943	r = 0.971
MCL2 and MCL3	r = 0.948	r = 0.981
BNL1 and BNL2	r = 0.984	r = 0.982
BNL1 and BNL3	r = 0.953	r = 0.985
BNL2 and BNL3	r = 0.964	r = 0.990
RTS1 and RTS2*	r = 0.821	r = 0.903

*Two best of three RTS in Noise

0.83; Left Ear: r = 0.05, p = 0.87) and participants with hearing loss (Right Ear: r = -0.49, p = 0.052; Left Ear: r = 0.04, p = 0.88).

Normality Analysis

The authors hypothesized that the ANL measurements would be normally distributed for children with normal hearing and children with hearing loss, and the Shapiro-Wilk Test of Normality was completed. The Shapiro-Wilk Test of Normality was not significant for children with normal hearing (W = 0.97, p = 0.80) or children with hearing loss (W = 0.94, p = 0.29), suggesting that ANL was normally distributed for both groups of children. These results follow the same pattern found in adults with and without hearing loss.

DISCUSSION

The purpose of this study was to examine ANLs in children with hearing loss. Additionally, the authors examined if a relationship exists between ANLs and speech perception in children with and without hearing loss, the reliability of ANLs in children with and without hearing loss, and the normality of the distribution of ANLs in children with and without hearing loss. The present study found that there were no significant differences in ANLs for children with normal hearing and children with hearing loss. Additionally, the present study found that there was not a significant relationship between ANLs and speech perception in noise in children with and without hearing loss, that ANLs were able to be obtained reliably in the pediatric population for both children with and without hearing loss, and that ANLs are normally distributed in children with and without hearing loss. These findings replicate the patterns found in ANLs studies for adults with and without hearing loss.

Only 1 out of 6 previous adult ANL studies revealed a significant relationship between ANL and speech understanding in noise tasks (Nabelek et al., 2004; Mueller et al., 2006; Nabelek et al., 2006; von Hapsburg et al., 2006; Plyler et al., 2008; Ahlstrom, et al., 2009). It was hypothesized that there could be a relationship between these two measures for children due to the fact that children younger than 13 years of age perform poorer on speech understanding tests than adults due to immaturity of the auditory system, smaller vocabulary, and reduced ability to use acoustic cues (Papso & Blood, 1989; Nittrouer & Boothroyd, 1990; Nilsson et al., 1996; Johnson et al., 1997; Fallon et al., 2000; Johnson, 2000; Fallon et al., 2002; Smaldino & Crandell, 2005). In this study, no significant correlation was found between ANL and RTS in noise, consistent with past findings in adult listeners (Nabelek et al., 2004; Mueller et al., 2006; Nabelek et al., 2006; von Hapsburg et al., 2006; Plyler et al., 2008).

Reasons for the different outcomes of this study in comparison to the Ahlstrom, et al. (2009) study might include the configuration of the participants hearing loss. The configuration for participants' in this study overall had a more flat shape when compared to participants' in the Ahlstrom et al. (2009) study where those participants had a more steeply sloping configuration shape. The linear regression in that study showed that a low unaided ANL score indicated a better performance on the unaided HINT measure. While most studies to date have not found a correlation between hearing thresholds and ANL, those research studies have only correlated hearing thresholds to ANL using the PTA (Nabelek et al., 1991; Nabelek et al., 2006; von Plyler et al., 2007; Plyler et al., 2008). Brännström and Olsen (2017) found that low frequencies (125 Hz, 250 Hz, and 500Hz)

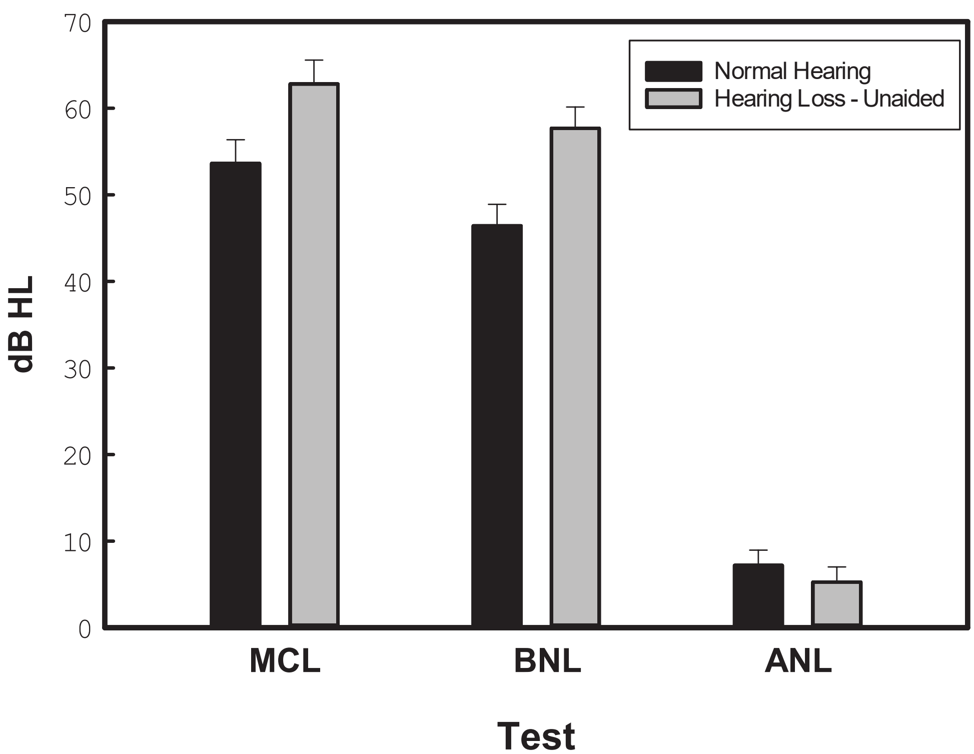


Figure 3. Mean and standard error for each group for the measures of MCL, BNL, and ANL.

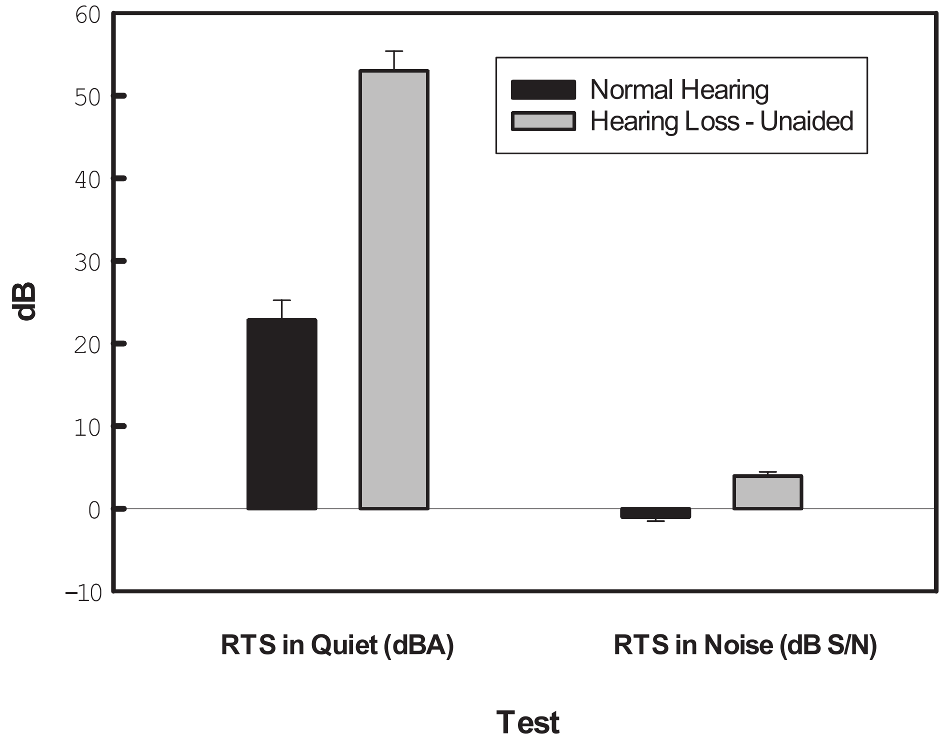


Figure 4. Mean and standard error for each group for the measures of RTS in quiet and RTS in noise.

were correlated to ANL and that the magnitudes of differences between the PTA for the low frequencies (average of 125 Hz, 250 Hz, and 500Hz) and PTA for the high frequencies (average of 1000 Hz, 2000 Hz, and 4000Hz) were correlated to ANL. The participants with poorer low frequency thresholds were more likely to have a lower ANL (< 7 dB), suggesting that they accepted more levels of noise. High ANLs (> 12 dB) were found in participants with a large difference between the PTA for low frequencies and PTA for high frequencies, suggesting that that a sloping hearing loss may contribute to those who are willing to accept less amounts of background noise. It is important to note that the Brännström and Olsen (2017) study did not use the traditional English version of ANL, but one developed by Brännström et al. (2012) utilizing Danish, Swedish, and non-semantic speech materials and different background noise (speech-weighted amplitude-modulated noise and multitalker babble noise).

Findings in the present study were compared to the two pediatric ANL studies. Means reported by Freyaldenhoven and Smiley (2006) were similar to those found in the present study. For example, the present study yielded mean ANL of 7.19 dB for children with normal hearing similar to the mean ANL of 9.7 dB previously reported. Results indicated children 6 to 12 years of age could complete the ANL task in a similar amount of time as an adult. The results of the present study were compared with findings from the Moore et al. (2011) study. Moore et al. (2011) reported a mean ANL of 8.50 dB for adults and a mean ANL of 7.82 dB for children, which were similar to mean ANLs in this study. The results of Moore et al. suggest that ANLs do not change throughout a person's life (from childhood to adulthood). A further comparison of the means and ranges of ANLs from various ANL studies are shown in Table 5. Freyaldenhoven and Smiley (2006) also reported a high re-test reliability ($r = 0.87$ $p < 0.001$) of ANLs in the pediatric population and that ANLs were normally distributed. The present study also found a high re-test reliability of ANLs in children with and without hearing loss. The present study examined the re-test reliability of MCL and BNL too since those are the measures used to obtain ANL, where Freyaldenhoven and Smiley (2006) calculated test-retest reliability using the ANL score only.

Limitations of this study include the lack of variability among the shape of the hearing loss configuration of the participants. Future studies should include a wide range of hearing loss configurations. Additionally, the language level of the Arizona Travelogue is unknown, which might have contributed to the non-significant findings in this population. Children may have been willing to accept more noise if the story was more kid-friendly. Future studies should examine the development of pediatric ANL test material to address this concern. Future directions of this research should include studies on aided ANL in the pediatric population, examining the effects of noise reduction algorithms on aided ANLs in the pediatric population, and assessing whether there is a relationship between ANL and hearing aid success in the pediatric population.

Summary

All ANL results for this study with pediatric listeners were consistent with ANL findings for adults with normal hearing and hearing loss. The results from this study support no significant relationships between ANLs and age, PTA, and speech perception in children with normal hearing and hearing loss. The findings also support that ANLs can be reliably obtained in children with and without hearing loss.

Table 5. Comparison of ANLs across multiple published studies.

Study	Mean ANL (SD) (in dB)	Range
Nabelek et al. (1991) N = 15 (elderly)	11.7 (7.6)	0.0-27.0
Nabelek et al. (1991) N = 15 (young adults)	15.9 (8.5)	5.0-37.0
Rogers et al. (2003) N = 50 (young adults)	10.9 (7.1)	0.0-24.7
Nabelek et al. (2004) N = 50 (adults)	9.6 (3.5)	Not reported
Freyaldenhoven et al. (2006) N = 30 (young adults)	12.9 (5.2)	4.0-24.0
Freyaldenhoven & Smiley (2006) N = 32 (children)	9.7 (6.2)	-2.7-21.7
Nabelek et al. (2006) N = 69 (older adults with HL & full-time HA users)	7.7 (3.0)	2.0-16.0
Nabelek et al. (2006) N = 69 (older adults with HL & part-time HA users)	13.5 (3.9)	9.0-26.0
Nabelek et al. (2006) N = 53 (older adults with HL & HA non-users)	14.4 (4.0)	9.0-27.0
von Hapsburg & Bahng (2006) N = 10 (young adults)	6.4 (6.3)	-2.0-20.0
Moore et al. (2011) N = 34 (young adults)	8.5 (6.7)	-2.7-24.7
Moore et al. (2011) N = 34 (children)	7.8 (5.1)	-1.3-17.3
Nichols & Gordon-Hickey (2012) N = 70 (young adults)	7.6 (6.9)	-4.0-26.0
Lowery & Plyler (2013) N = 30 (adults with HL)	13.3 (8.0)	-6.0-32.0
Gordon-Hickey & Morlas (2015) N = 44 (older adults)	5.4 (6.9)	Not reported
Present Study N = 16 (children with normal hearing)	7.2 (6.3)	-2.0-20.0
Present Study N = 16 (children with hearing loss)	5.3 (8.1)	-6.0-26.0

REFERENCES

Ahlstrom, J.B., Horwitz, A.R., & Dubno, J.R. (2009). Spatial benefit of bilateral hearing aids. *Ear and Hearing, 30*(2), 203-218.

American National Standards Institute (1996). *Specifications for Audiometers* (ANSI S3. 6-1996). New York: American National Standards Institute.

American National Standards Institute (1999). *Maximum Ambient Noise Levels for Audiometric Test Room* (ANSI S3. 1-1999). New York: American National Standards Institute.

Bilger, R.C., Neutzel, J.M., Rabinowitz, W.M., & Rzeczkowski, C. (1984). Standardization of a test of speech perception in noise. *Journal of Speech Language and Hearing Research*, 27, 32-48.

Brännström, K.J., Lantz, J., Holme Nielsen, L., & Olsen, S.O. (2012). Acceptable noise level with Danish, Swedish, and non-semantic speech materials. *International Journal of Audiology, 51*, 146–156.

Brännström, K.J. & Olsen, S.O. (2017). The acceptable noise level and the pure-tone audiogram. *American Journal of Audiology, 26*, 80-87.

Corbin, N.E., Bonino. A.Y., Buss, E, & Leibold, L. (2016). Development of open-set word recognition in children: Speech-shaped noise and two-talker speech maskers. *Ear and Hearing, 37*(1), 55-63.

Elliott, L.L. (1979). Performance of children aged 9 to 17 years on a test of speech intelligibility in noise using sentence material with controlled word predictability. *Journal of the Acoustical Society of America, 66*(3), 651-653.

Fallon, M., Trehhub, S.E., & Schneider, B.A. (2000). Children's perception of speech in multitalker babble. *Journal of the Acoustical Society of America, 108*(6), 3023-3029.

Fallon, M., Trehhub, S.E., & Schneider, B.A. (2002). Children's use of semantic cues in degraded listening environments. *Journal of the Acoustical Society of America, 111*(5), 2242-2249.

Flexer, C. (2005). Rationale for the Use of Sound Field Systems in Classrooms: The Basis of Teacher In-Services. In C.C. Crandell, J.J. Smaldino, & C. Flexer (Eds.), *Sound Field Amplification: Applications to Speech Perception and Classroom Acoustics Second Edition*. (pp.3-22). Clifton Park, NY: Thompson Delmar Learning.

Franklin Jr., C.A., Thelin, J.W., Nabelek, A.K., & Burchfield, S.B. (2006). The effect of speech presentation level on acceptance of background noise in listeners with normal hearing. *Journal of the American Academy of Audiology, 17*, 141-146

Freyaldenhoven, M.C., Nabelek, A.N., Burchfield, S.B., & Thelin, J.W. (2005a). Acceptable noise level as a measure of directional hearing aid benefit. *Journal of the American Academy of Audiology, 16*, 228-236.

Freyaldenhoven, M.C., Plyler, P.N., Thelin, J.W., & Hedricks, M.S. (2007). The effects of speech presentation level on acceptance of noise in listeners with normal and impaired hearing. *Journal of Speech, Language, and Hearing Research, 50*, 878-885.

Freyaldenhoven, M.C. & Smiley, D.F. (2006). Acceptance of background noise in children with normal hearing. *Journal of Educational Audiology, 13*, 28-32.

Freyaldenhoven, M.C., Thelin, J.W., Plyler, P.N., Nabelek, A.K., & Burchfield, S.B. (2005b). Effect of stimulant medication on the acceptance of background noise in individuals with Attention Deficit/Hyperactivity Disorder. *Journal of the American Academy of Audiology, 16*, 677-686.

Gordon-Hickey, S. & Moore, RE. (2007). Influence of music and music preference on acceptable noise levels in listeners with normal hearing. *Journal of the American Academy of Audiology, 18*(5), 417-427.

Hall, J.W. III, Grose, J.H., Buss, E. et al. (2002). Spondee recognition in a two-talker masker and a speech-shaped noise masker in adults and children. *Ear and Hearing, 23*, 159-165.

Harkrider, A.W., & Smith, S.B. (2005). Acceptable noise levels, phoneme recognition in noise, and measures of auditory efferent activity. *Journal of the American Academy of Audiology, 16*, 530-545.

Jamison, D.G., Kranjc, G., Yu, Karen, & Hodgetts, W.E. (2004). Speech intelligibility of young school-aged children in the presence of real-life classroom noise. *Journal of the American Academy of Audiology, 15*, 508-517.

Johnson, C.E. (2000). Children's phoneme identification in reverberation and noise. *Journal of Speech Language and Hearing Research, 43*, 41-157.

Johnson, E., Ricketts, T., Hornsby, B. (2009). The effect of extending high-frequency bandwidth on acceptable noise level (ANL) of hearing-impaired listeners. *International Journal of Audiology, 48*, 353-362.

Johnson, C.E., Stein, R.L., Broadway, A., & Markwalter, T.S. (1997). "Minimal" high-frequency hearing loss and school-age children: Speech recognition in a classroom. *Language, Speech, and Hearing Services in Schools, 28*, 77-85.

Moore, RE, Gordon-Hickey, S, & Jones, AL. (2011). Most comfortable listening levels, background noise levels, and acceptable noise levels for children and adults with normal hearing. *Journal of the American Academy of Audiology, 22*(5), 286-293.

Mowrer, OH. (1958). Hearing and Speaking: An analysis of language learning. *Journal of Speech and Hearing Disorders, 28*(2), 143-152.

Mueller, HG, Weber, J, & Hornsby, BWY. (2006). The effects of digital noise reduction on the acceptance of background noise. *Trends in Amplification, 10*(2), 83-93.

Nabelek, A.K., Freyaldenhoven, M.C., Tampas, J.W., Burchfield, S.B., & Muenchen, R.A. (2006) Acceptable noise level as a predictor of hearing aid use. *Journal of the American Academy of Audiology, 17*, 626-639.

Nabelek, A.K., Tampas, J.W., & Burchfield, S.B. (2004). Comparison of speech perception in background noise with acceptance of background noise in aided and unaided conditions. *Journal of Speech Language and Hearing Research, 47*, 1001-1011.

Nabelek, A.K, Tucker, F.M., & Letowski, T.R. (1991). Toleration of background noises: Relationship with patterns of hearing aid use by elderly persons. *Journal of Speech Language and Hearing Research, 34*, 679-685.

Neuman, A.C., Wroblewski, M., Hajicek, J., & Rubenstein, A. (2010). Combined effects of noise and reverberation on speech recognition performance of normal hearing children and adults. *Ear and Hearing, 31*(3), 336-344.

Nichols, A.C. & Gordon-Hickey, S. (2012). The relationship of locus of control, self-control, and acceptable noise levels for young listeners with normal hearing. *International Journal of Audiology, 51*(4), 353-359.

Nilsson, MJ, Soli, SD, & Gelnett, DJ. (1996). Development of the Hearing in Noise Test for Children (HINT-C). *House Ear Institute*, Los Angeles, CA.

Nishi, K., Lewis, D.E., Hoover, B.M., et al. (2010). Children's recognition of American English consonants in noise. *Journal of the Acoustical Society of America, 127*, 3177-3188.

Nittrouer, S. & Boothroyd, A. (1990). Context effects in phoneme and word recognition by young children and older adults. *Journal of the Acoustical Society of America, 87*(6), 2705-2715.

Papso, CF, & Blood, IM. (1989). Word recognition skills of children and adults in background noise. *Ear and Hearing, 10*(4), 235-236.

Plyler, PN, Bahng, J, & von Hapsburg, D. (2008). The acceptance of background noise in adult cochlear implant users. *Journal of Speech Language and Hearing Research, 51*, 502-515.

Plyler, P.N., Madix, S.G., Thelin, J.W., & Johnston, K.W. (2007). Contribution of high-frequency information to the acceptance of background noise in listeners with normal and impaired hearing. *American Journal of Audiology, 16*, 149-156.

Recker, K.L. & Edwards, B.W. (2013). The effect of presentation level on normal-hearing and hearing-impaired listeners speech and noise levels. *Journal of the American Academy of Audiology, 24*, 17-25.

Recker, K.L. & Micheyl, C. (2017). Speech intelligibility as a cue for acceptable noise levels. *Ear & Hearing, 38*(4), 465-474.

Rogers, D.S., Harkrider, A.W., Burchfield, S.B., & Nabelek, A.K. (2003). The influence of listener's gender on the acceptance of background noise. *Journal of the American Academy of Audiology, 14*(7), 372-382.

Smaldino, JJ, & Crandell, CC. (2005). Speech Perception in the Classroom. In CC Crandell, CC, Smaldino, JJ& Flexer C ed. *Sound Field Amplification: Applications to Speech Perception and Classroom Acoustics Second Edition*. Clifton Park: Thompson Delmar, 49-56.

Tampas, J.W., & Harkrider, A.W. (2006) Auditory evoked potentials in females with high and low acceptance of background noise when listening to speech. *Journal of the Acoustical Society of America, 119*(3), 1548-1561.

von Hapsburg, D, & Bahng, J. (2006). Acceptance of background noise levels in bilingual (Korean-English) listeners. *Journal of the American Academy of Audiology, 17*, 649-658.

Wightman, F.L. & Kistler, D.J. (2005). Informational masking of speech in children: Effects of ipsilateral and contralateral distractors. *Journal of the Acoustical Society of America, 118*, 3164-3176.

ABOUT THE AUTHORS

Dr. Alisha Jones earned her Bachelor of Science degree in speech and hearing sciences, AuD, and PhD, in audiology from the University of South Alabama, Mobile, Alabama. She is currently an assistant professor at Auburn University, Auburn, Alabama.

Dr. Robert Moore is an Emeritus Associate Professor and Chair in the Department of Speech Pathology and Audiology at the University of South Alabama. His areas of research are speech perception in noise and psychoacoustics (pitch perception).

The authors report no conflict of interest.

Appendix A

PARTICIPANT INSTRUCTIONS FOR ANL TASKS

Instructions for establishing Most Comfortable Listening Level: “I’m going to play a story for you to listen to through the headphones. The story is going to be very soft at first. I want you to turn the volume of the story up by giving me a thumb up sign. Turn the sound up until it is where you can hear the story like on a radio. Remember, if it gets too loud, you can turn down the volume by using a thumb down sign.”

Instructions for establishing Background Noise Level: “You will listen to the same story. Now, I’m going to add noise at the same time. The story will stay at the same volume. The noise will start out soft and then you turn the noise up or down to the most noise that you would be willing to listen to and still be able to listen to the story for a long time.”

PARTICIPANT INSTRUCTIONS FOR HINT-C TASKS

I am now going to play a list of sentences. Please repeat the whole sentence. At first the sentences will be easy to hear and understand, but then I will add noise in the background. The sentences may become harder to hear and understand. Please repeat the sentences back to me the best you can and it is okay if you miss some of the words. We will first do a practice list.

Single-Sided Deafness: A Case Study of Missed Opportunities

Cheryl DeConde Johnson, EdD
ADEvantage - Audiology Deaf Education Vantage Consulting
Leadville, CO

Carla Zimmerman, CCC-SLP, LSLS Cert. AVEd
Zimmerman Speech & Hearing Center
Tempe, AZ

The implications of single-sided deafness (SSD) are not readily recognizable because these are children who usually speak well and are observed to hear sufficiently. People unfamiliar with this level of hearing look elsewhere to attribute learning and behavior difficulties. The case of a boy's educational and emotional journey through elementary school is described. Even though he was implanted with a bone anchored hearing device, his hearing status was totally disregarded as a contributing factor to his school performance, including his special education services. This case is particularly troubling because the lack of proper assessment and intervention contributed to significant social-emotional and behavioral issues that escalated as the student aged, in addition to learning challenges. The case culminated in a due process hearing in sixth grade and eventual placement in private school.

INTRODUCTION

The authors were involved in the due process hearing described in this case presentation, serving in the capacities of expert witness and independent educational evaluator. As more was learned about the young man and his situation, it seemed inconceivable that a school district could be so negligent in their disregard for considering the impact of reduced hearing on listening, learning, language and academic performance. The situation motivated the authors to share this case to raise awareness about the potential implications of single-sided deafness (SSD). This case is particularly troubling because the lack of proper assessment and intervention contributed to significant social-emotional and behavioral issues, in addition to academic difficulties. These difficulties escalated as the student aged, culminating in the due process hearing in sixth grade. The student's name and some other facts have been changed to protect anonymity.

EARLY HISTORY

Little is known of Kevin's early history. His biological mother was reported to have bipolar disorder and a history of drug use. Since the age of 4, Kevin and his younger sister lived with their grandparents and were adopted by them two years later. The children referred to the grandparents as mother and father. Kevin attended a community preschool and, at school entry, there were no significant learning or medical issues reported.

SCHOOL HISTORY

Kindergarten

Kevin passed kindergarten hearing screening, but his teacher noted difficulties with "listening comprehension" on a progress report (missed opportunity #1). Also noticing some potential listening problems, his mother consulted his pediatrician over the summer who referred Kevin to an ENT practice where the audiologist diagnosed single-sided deafness in the right ear. The pediatrician also diagnosed attention-deficit hyperactivity disorder (ADHD) for which Kevin subsequently used a homeopathic treatment.

First Grade

At the start of first grade, Kevin's mother referred Kevin for evaluation for special education. The multidisciplinary educational team (MET) assessed needs for speech-language and occupational therapy but did not further assess auditory function instead citing the ENT audiologist's report findings which reported 100% speech discrimination (missed opportunity #2). His mother related to the IEP team that Kevin "is easily frustrated…can be bossy…lacks social skills…[has] problems interacting with other children…tends to give up easily when learning something new…[throws] temper tantrums."

Kevin's primary eligibility was determined to be Other Health Impairment (due to ADHD) with speech-language as the secondary disability due to receptive and expressive language delays (missed opportunity #3). Though there were also concerns related to hyperactivity, conduct problems, atypicality, withdrawal, and attention problems, a Functional Behavior Analysis indicated his behavior was attention seeking. Neither the school district audiologist nor teacher of the deaf/hard of hearing was invited or present at the eligibility or IEP meetings (missed Opportunity #4), and there was no recognition of his hearing status, or accommodations to address it, in his IEP (missed opportunity #5).

Second & Third Grade

In August prior to second grade, Kevin received a bone anchored hearing aid which was activated the following March. The IEP Annual Review indicated the "hearing aid" was discussed, but no audiologist or teacher of the deaf/hard of hearing was involved, and no adjustments to the IEP were made (missed opportunity #6). There was no change for third grade, though it was noted that he met standards on state tests.

Fourth Grade

Kevin was staffed out of special education at his three-year eligibility meeting. No additional testing was completed (missed opportunity #7) as it was determined he had met his special education goals and that he was a "model" student. The MET noted that his ADHD disability was still present but did not require specially designed instruction. His grades were mostly B's & C's with a D in math. On state tests, his scores ranged from Minimally Proficient (Math) to Partially Proficient (English Language Arts). A 504 Plan was not considered (missed opportunity #8).

Fifth Grade

Kevin's grades for this year included a C in Math (a D in Quarter 3) and a C in Reading (D in Quarter 2). He scored as Partially Proficient on his state tests.

Sixth Grade

Because of three reports of discipline issued in one month (inappropriate language, threw an object at a student) resulting in in-school suspension, Kevin's mother requested a new special education evaluation citing his declining grades, behavior issues, and hearing concerns.

The MET, again, did not include the educational audiologist or teacher of the deaf/hard of hearing (missed opportunity #9) but reported in the records that he had failed hearing screening annually. The MET recommended additional assessments in the following areas were needed to determine eligibility: general intelligence, academics, communication, social/emotional, and motor/sensory plus a Functional Behavior Analysis to evaluate the basis of Kevin's argumentative behavior/noncompliance (missed opportunity #10).

Comprehensive MET Evaluation

The MET results indicated overall average ability (working memory was low average), a probable emotional behavioral disorder that was attributed to an intention to get adult and peer attention, difficulty making inferences, and below average academic achievement requiring intervention and accommodations. At the eligibility meeting, the MET reported that Kevin's current difficulties were not primarily the result of adverse impact of "deafness in the right ear" (missed opportunity #11). Even considering the test findings, disability eligibility was again determined as Other Health Impairment due to ADHD. Although Kevin's mother asked for evaluations related to audiology and hearing impairment, she was denied (missed opportunity #12).

DUE PROCESS

Following the denial, Kevin's mother sought legal advice and asked for an Independent Educational Evaluation (IEE) at school expense to obtain educational audiology, speech and language, psychoeducational and occupational therapy evaluations. The district denied the audiology and speech-language evaluations because the district had not completed assessments in those areas (missed opportunity #13). At this point, Kevin's mother filed the due process complaint and notified the school that she was bringing her attorney to the IEP meeting. In response, the district invited the educational audiologist to attend the IEP meeting though this individual had not assessed Kevin.

IEP Meeting

Assessment results emphasized that Kevin struggles with controlling symptoms related to his diagnosis of ADHD including difficulties with focus and attention, poor listening skills, and being in trouble for not paying attention, and that he is extremely self-conscious about his "hearing aid implant" which also impacts his mood. The educational audiologist summarized Kevin's most recent private evaluation citing his excellent aided benefit in quiet situations. As a need, the audiologist included that, to increase Kevin's communication ability, the school district could provide assistive technology including a classroom or personal FM amplification device. Under the IEP Special Considerations section, the MET indicated that the "Statement of the Language Needs, Opportunities for Direct Communication with Peers in the Child's Language and Communication Mode", was not needed (missed opportunity #14).

The IEP goals offered pertained only to Kevin's behavioral concerns, none of which addressed the underlying concerns that were impacting his behavior (missed opportunity #15). IEP services offered included:

- Behavior support in the general education classroom to include disability awareness training and self-advocacy skills, provided by the special education teacher;
- An annual audiogram provided by the district audiologist or parent's private audiologist through private insurance;
- Assistive technology in the form of speech-to-text training to support initiation and writing activities, provided by a paraprofessional, teacher, or staff;
- Audiological support in the form of an FM system while in the general education setting, provided by the audiologist (1 hour/semester);
- Supports for school personnel in the form of speech-to text-training and FM system training to incorporate universal application across the campus, provided by a teacher or staff and audiologist; and,
- A Behavior Intervention Plan.

Kevin's mother did not sign the IEP pending outcomes of the Due Process proceedings.

Independent Educational Evaluation (IEE)

A comprehensive speech and language evaluation was conducted, utilizing the Clinical Evaluation of Language Fundamentals – 5th Edition (CELF 5, Wiig, Semel, and Secord, 2013), which consists of several subtests that are designed to assess specific language skills, and the Test of Language Competence-Expanded Edition (TLC-E, Wiig and Secord, 1989), which targets a student's ability to use strategies in acquiring communicate competence and metalinguistic ability. On the CELF 5, there was subtest scatter, with scores ranging from very low to above average. There was a statistically significant difference between Kevin's ability to understand language and his ability to express himself. Additionally, there was a statistically significant difference between his semantic knowledge and his ability to apply memory to language tasks. His relatively stronger skills with receptive language and semantic knowledge may have led his school team to believe that his language skills were uniformly robust. His relative weaknesses with expressive language and his ability to apply memory to language tasks were not recognized by his school team. On the TLC-E, scores ranged from very low to low average. Kevin struggled with the metalinguistic skills needed to interpret and utilize complex language. Students who struggle with these skills experience difficulties with both processing and production of language, which can have a significant negative impact on the performance of the complex academic tasks required of adolescents.

Test effort was an issue throughout the evaluation. Kevin struggled to create sentences and was frustrated, banging his chin on the table and crying. His productions were characterized by false starts, stopping, restarting, and very long pauses while he reformulated his sentence mentally. He frequently made self-corrections, including corrections after an item had passed. These behaviors have implications for classroom performance. In the classroom setting, if Kevin was engaged in rethinking while the rest of the class was moving ahead, he was likely to be "lost". Overall, Kevin's scores appeared to be better than his actual functioning, as a great deal of effort and self-correction was noted. In a rapidly-paced classroom, he would not have the luxury of time that the testing environment affords.

A Functional Listening Evaluation (Johnson, 2013) was conducted, and results were averaged, comparing Common Phrases vs Nonsense Phrases. The results are summarized below.

- Common Phrases (evaluates ability to use linguistic knowledge to fill in the blanks)
  - o Effect of Noise – quiet 99%, noise 96%
  - o Effect of Distance – close 99%, distant 96%
  - o Effect of Visual Input – auditory + visual 98%, auditory only 98%
- Nonsense Phrases (evaluates ability to understand words without topic knowledge)
  - o Effect of Noise – quiet 74%, noise 51%
  - o Effect of Distance – close 66%, distant 59%
  - o Effect of Visual Input – auditory + visual 66%, auditory only 59%

The most telling scores were in Kevin's difficulty understanding nonsense phrases (Table 1). In this task, he was not able to rely on his prior knowledge to fill in the gaps. He dropped to 30% accuracy when he did not have visual input with soft speech in the presence of noise, and he could not use context to fill in the blanks.

Table 1. Kevin's performance on the Nonsense Phrases section of the Functional Listening Evaluation (Johnson, 2013).

SPEECH UNDERSTANDING NONSENSE PHRASES	**Close/quiet**	**Close/noise Effect of noise**	**Distant/quiet Effect of distance**	**Distant/noise Effect of noise + distance**
Auditory and visual	70%	65%	75%	50%
Auditory only *Effect of loss of visual input*	70%	60%	80%	30%

Kevin also completed the Classroom Participation Questionnaire (CPQ, Antia, Sabers, & Stinson, 2007). The CPQ is designed to obtain information regarding an individual student's participation in the general education classroom. The self-assessment is a series of 16 statements each rated on a 4 point scale: 1 = *almost never*, 2 = *seldom*, 3 = *often*, 4 = *almost always*. After reading each question, Kevin circled the number that corresponded to his perception of his ability. The questions were analyzed in four subscales: Understanding Teacher, Understanding Students, Positive Affect, and Negative Affect.

All average subscale scores were below the desirable ratings indicating a significant impact on Kevin's ability to participate in class as well as his academic achievement. His scores further illustrated the frustration he felt regarding his interactions with his teacher and classmates. CPQ scores are significantly correlated with academic achievement lending support to the notion that students who participate, and who feel positively about their participation, are more likely to do well academically.

Due Process Outcomes

The administrative law judge assigned to the case requested that both sides use the mediation process to resolve the issues. The negotiated settlement by the attorney required the school district to pay for Kevin's placement in a private school that focuses on students with unique learning needs and compensatory services.

SUMMARY & REFLECTION

Kevin's educational team erred from the start by relying on the report of his private audiologist, who indicated that his aided speech perception in quiet was 100%. If his audiologist had performed testing under conditions that more closely mirrored the challenges of listening in the constantly changing environment of a classroom, there may have been a better understanding of the impact of Kevin's SSD.

The Missed Opportunities

The fifteen missed opportunities included several procedural violations of this student's right to a free and appropriate public education (FAPE). The quantity of failures listed below reflect the impact of the lack of awareness of the effects of reduced hearing by the entire multidisciplinary team and, subsequently, a total disregard for IDEA as it applies to students who are deaf and hard of hearing.

- Failure to rescreen hearing when kindergarten teacher expressed concern.
  - District is required to ensure all children with disabilities are identified, located, and evaluated (Child Find, (§300.111).
- Failure to conduct assessment according to IDEA requirements. (Denial of FAPE)
  - A full evaluation in all areas of suspected disability meaning a variety of assessment tools and strategies to gather relevant functional, developmental, and academic information about the child, including information provided by the parent (§300.304(a)(1)).
- Failure to recognize the possible implications of single-sided deafness.
- Failure to identify hearing impairment as a disability category.
- Failure to address the special factors (communication considerations for children who are deaf or hard of hearing) (§300.324(2)(iv)).
- Failure to offer a 504 Plan once Kevin was determined to no longer meet special education eligibility criteria even though the district stated that Kevin still had a disability of ADHD.

Kevin had not been considered through the lens of a child with reduced hearing. Many of the struggles he experienced could be attributed directly to his hearing status. His educational history and test performance, both in the IEE and in the district evaluation, might not raise red flags to professionals who do not specialize in the unique needs of deaf and hard-of-hearing children. His subtest profiles, however, coupled with his hearing condition, raised concerns that occur frequently with children with reduced hearing. Lack of knowledge of the effects that SSD can have on a child's academic performance and social-emotional and behavioral functioning can lead to a reactive or "failure-based" approach towards intervention (Winiger, Alexander, Diefendorf, 2016). By recognizing the significant effect of hearing conditions like Kevin's, support and intervention efforts can be proactive and can lead to successful academic and social functioning.

REFERENCES

Antia, S., Sabers, D., & Stinson, M. (2007). Validity and reliability of the classroom participation questionnaire with deaf and hard of hearing students in public schools. *Journal of Deaf Studies and Deaf Education, 12*(2), 158-171.

Johnson, C.D. (2013). Functional Listening Evaluation. Available from: https://adevantage.com/resources.

Wiig, E. H., & Secord, W. (1989). Test of Language Competence-Expanded Edition. New York: The Psychological Corporation.

Wiig, E. H., Semel, E., Secord, W. A. (2013). Clinical Evaluation of Language Fundamentals–Fifth Edition (CELF-5). Bloomington, MN: NCS Pearson.

Winiger, A, Alexander, J, & Diefendorf, A. (2016) Minimal hearing loss: From a failure-based approach to evidence-based practice. *American Journal of Audiology, 25*, 232-245.

The Brazilian Phrases in Noise Test (PINT Brazil)

Larissa Germiniani dos Santos, PhD
University de São Paulo

Erin C. Schafer, PhD
University of North Texas

Linda Thibodeau, PhD
The University of Texas at Dallas

Regina Tangerino de Souza Jacob, PhD
University de São Paulo

The goal of this study was to determine if the Phrases in Noise Test (PINT), which is recorded in English, could be adapted for the assessment of the hearing skills in children in the Brazilian population from the age of four-years old. The steps to adapt the PINT Brazilian Portuguese included translation of the stimuli, testing cultural equivalence (verify that children understand the stimuli), record the stimuli, adjust the stimuli for equal intelligibility, and create and validate the final test lists. To validate the test lists, the speech recognition of 10 children was evaluated.

Introduction

Brazil has a public policy structured on Hearing Health. The acquisition of technological aids is considered essential in the process of hearing rehabilitation for children and adults. Hearing technology may be obtained in the accredited Hearing Health Services and with the criteria indicated by the Unified Health System (UHS) at no cost for the population.

Children with hearing loss and hearing aids require even greater effort than their peers with normal hearing when listening in adverse acoustic conditions (especially in classrooms), and all school children exposed to noisy environments at an early age (Hicks & Tharpe, 2002). Since 2013, the last concession in the UHS in the Hearing Health area was the provision of an assistive device known as frequency modulation (FM) systems, which is a device that improves the signal-to-noise ratio at the listener's ear. This ordinance was considered a great achievement by hearing health providers because it enabled the use of FM systems by children and teenagers with hearing loss in the school environment. The FM system is beneficial to children with hearing aids (HA) and/ or cochlear implants (CI) because children with hearing loss have significant difficulty hearing in noisy environments and because will allow the listener to be able to hear the speech at a higher intensity level than when not using it (Jacob & Queiroz- Zattoni, 2011; Thibodeau & Schaper, 2014; Mulla & McCraken, 2014; Thibodeau & Wallace, 2014; Atcherson, 2014; Saunders et al., 2014).

The American Academy of Audiology (AAA, 2008, 2011) developed clinical practice guidelines for assessing the benefit of remote microphone systems, such as an FM system. The guidelines recommend a behavioral verification procedure consisting of speech perception in noise measures (AAA, 2008, 2011). The guideline also supports that fact that the measurement of communicative and hearing abilities of children with hearing loss is critical for monitoring progress as part of their rehabilitative program.

In Brazil, there is no standardized test for assessing children's speech recognition in noise. The only tests with accompanied noise are appropriate only for adults and include the Brazilian Hearing in Noise Test - HINT/ Brazil (Bevilacqua et al., 2008) and the test Lista de Sentenças em Português- LSP (Costa, 1998) (Jacob et al., 2011).

Tests that are appropriate for children may be used only to assess speech recognition in quiet. These tests were adapted from standardized tests used internationally and include the Tacam - Test of Minimal Hearing Capacity, which was adapted for Brazilian Portuguese by Orlandi & Bevilacqua (1999) and adapted from Early Speech Perception Test - ESP (1990). It can be used for children up to 5 years of age and assesses closed-set speech perception through the use of toys that correspond to the test stimuli. Another test, the GASP - Procedure for the Evaluation of Children with Profound hearing loss, adapted by Bevilacqua &Tech (1996), examines the skills of hearing detection and discrimination, auditory recognition and understanding of words in a closed set. The List of Dissyllable Words, proposed by Delgado & Bevilacqua (1999), evaluates open set word recognition.

Schafer et al. (2012) affirm that the number of research studies on the speech perception in noise in young children is limited, which is likely related to the lack of speech-in-noise tests specific to the pediatric population. The authors explain that the Hearing In Noise Test Children - HINT-C (Nilsson et al., 1996) and Bamford-Kowal-Bench Speech-in-Noise test- BKB-SIN (Etymotic Research, 2004), which are tests not translated into Portuguese Brazilian, contain vocabulary levels that are equal to or exceed that of typical 5- or- 6-years-old child. Also, these tests may not be sensitive or efficient because they use fixed-signal levels, which result in ceiling and floor effects (0% or 100% correct) when the signal-to-noise ratio (SNR) is too easy or difficult for a particular child. Other examples of speech perception tests in noise are described in the literature and include the Listening in Spatialized Noise Test (LISN®) composed of 120 sentences (Cameron & Dillon, 2007) and Leuven Intelligibility Number Test (LINT) (Van Deun, Wieringen and Wouters, 2010).

Because there are no speech-in-noise tests in Portuguese Brazilian, it is imperative to consider if an existing test can be adapted to allow for testing with wireless technology, such as FM systems. Schafer & Thibodeau (2006) developed and validated a list of phrases for preschoolers that involved body parts. The test results provide a sensitive estimate of a young child's speech-in-noise threshold; the test should not be negatively influenced by a child's receptive vocabulary level or by the child's intelligibility to the examiner. Schafer & Thibodeau (2006) used the Phrases in Noise Test (PINT) to determine the benefit of FM systems in young children with cochlear implants and detected significant improvements when the FM systems were in use relative to the cochlear implant alone. The motivation for the present study was to determine if the PINT could be adapted for the assessment of the hearing skills in children in the Brazilian population from the age of four-years old.

METHODS

This study was conducted in the Department of Speech-Language Pathology and Audiology of the School of Dentistry of Bauru Clinic at University de São Paulo (FOB/ USP). The study was approved by the University Research Ethics Committee.

Instrument and Procedures

The PINT test was developed originally for children with cochlear implants by Schafer (2005) and Schafer & Thibodeau (2006) and was reviewed and modified by Schafer et al. (2012). The goal of this test was to obtain speech-in-noise recognition thresholds of young children without the influence of variables related to the level of receptive vocabulary or intelligibility of speech produced by the child (i.e., articulation).

The PINT estimates 50% correct thresholds for phrases in the presence of ascending and descending levels of multiclassrom noise. It is comprised of 12 simple-order sentences related to the parts of the body and is recorded with a female voice. The intensity of the speech stimulus is fixed, and the noise is presented at varying intensities. These phrase stimuli were selected assuming that most children are familiar with parts of the body from a small age (Weaver et al., 1979). Noise was recorded in several real classrooms during independent work time and was, then, overlapped digitally using acoustic editing software. The noise samples were overlapped to reduce the peaks and valleys (i.e., silent periods) that occur in single-classroom noise samples. This type of noise was selected to simulate conditions experienced by most school-age children. Classroom noise is expected to be more challenging than other non-significant noises, such as steady-state, speech-shaped noise (Sperry et al., 1997).

Cross-Cultural Adaptation

We first made contact with the authors of the PINT test who authorized the translation and cultural adaptation of the PINT Test, into Brazilian Portuguese. The translation and the cross-cultural adaptation of the PINT (Schafer, 2005; Schafer & Thibodeau, 2006; Schafer et al., 2012) followed the stages recommended by Guillemin, Bombardier, and Beaton (1993).

The first step was to translate (forward) the original English language instrument into Portuguese. The original instrument was given to two English translators and interpreters, fluent in this language, who did not know each other and had no knowledge of the test. The purpose was to elaborate, individually and in confidentiality, the first Portuguese version. This procedure aimed at generating two independent translations of the test.

The group of revisers comprised two speech-language pathologists (Brazilian individuals who were fluent in English) who analyzed the two resulting documents, reduced the differences found in the translations, and adapted the text to the Brazilian culture. Thus, a new test named "PINT Brazil" was created. The phrases that were translated and adapted from the PINT test are provided in Table 1.

Table 1. Phrases translated and adapted for the Brazilian Portuguese

Phrases in English	Phrases in Portuguese
Hold his hand	Segure a mão
Brush his teeth	Escove os dentes
Touch his tongue	Toque a barriga
Wipe his mouth	Limpe a boca
Blow his nose	Aperte o nariz
Stomp his feet	Bata os pé
Comb his hair	Penteie o cabelo
Hide his face	Esconda o rosto
Find his shoe	Mostre o sapato
Pat his leg	Bata na perna
Move his arm	Mexa o braço
Pull his toes	Puxe o dedão do pé

For the revision of grammatical and idiomatic equivalence, a copy of the test was sent to two other translators who had the same linguistic and cultural characteristics of the translators used in the first stage. Without any knowledge of the original text, they produced the English counterpart of the new version of the instrument. The same group of revisers evaluated the two resulting versions, comparing them to the original in English.

In this stage, cultural adaptation, the purpose was to establish a cultural equivalence between the English and Portuguese versions of the test. Cultural equivalence is achieved when at least 80% of the population understands the sentences. We tested a group of 10 children with normal hearing sensitivity, five boys and five girls with a mean age of seven years, who spoke Portuguese fluency, and 100% of them understood all the sentences.

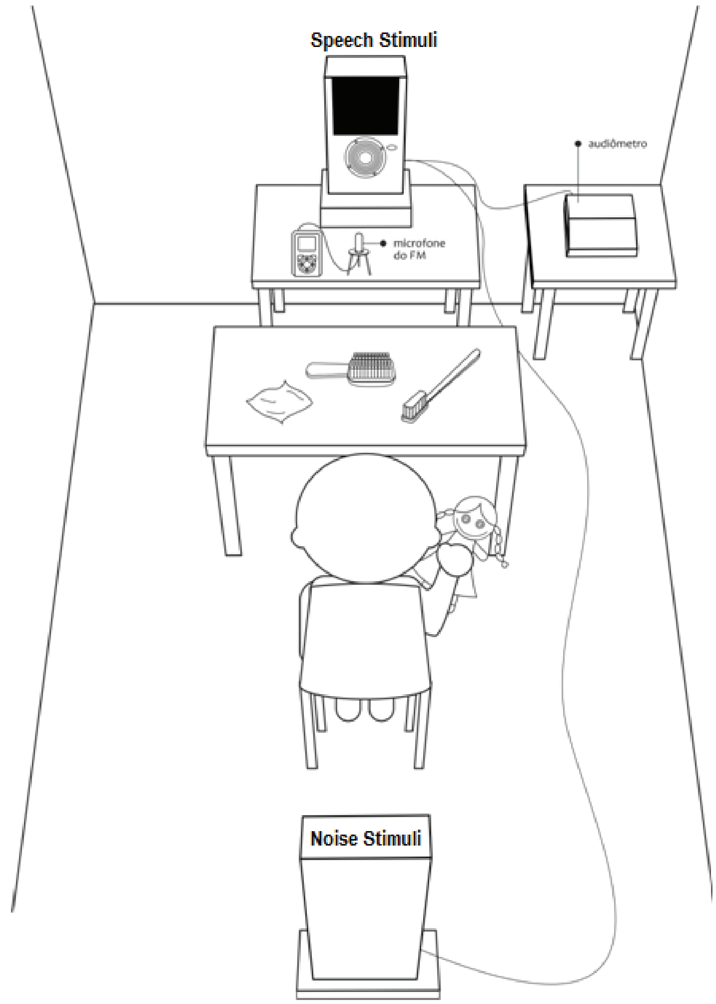
Participants

The participants included 10 children with normal hearing sensitivity (5 boys and 5 girls from 4 to 11 years, mean age 7 years old) and 10 adults with normal hearing sensitivity (6 female and 4 male from 19 to 25 years). The participants had Portuguese as a first language and no history of recurrent otitis media, middle ear surgery, use of ototoxic drugs, speech-language delays, and/or hearing difficulties. The following tests were conducted to confirm normal hearing: otoscopy, a pure tone hearing screening (500, 1000, 2000 and 4000 Hz) with a pass criterion of 25 dB HL at each frequency and in each ear, transient evoked otoacoustic emissions (Otoport Lite/ Otodynamics Ltd), tympanometry, and ipsilateral acoustic reflex (Titan/Interacoustics S/A).

Test Environment and Equipment

Testing was conducted in an acoustically-treated room in the Audiology Clinic (ANSI standards). The AC40 full two-channel audiometer (version 1.69 USA) was used to present the stimuli, and speech and noise stimuli were presented from two, head-level loudspeakers located at 0- and 180-degrees azimuth, respectively (i.e., S0/N180). Each speaker was located at a distance of one meter from the listener who was seated in a chair placed in the center of the room as shown in Figure 1.

Figure 1. Application Scenario the PINT Brazil



Speech Stimuli

Speech stimuli were recorded by a female talker in an acoustically-treated studio. Afterwards, using acoustic editing software (Cool Edit Pro 2.1 and Pro Tools HDX 10.3.5), the phrases were adjusted to reduce the root mean square (RMS) intensity and duration across the sample to allow for reliable testing of speech-in-noise threshold. In the software, the time-stretching function, which modifies the number of pitch periods in the signal, was used to modify the duration of the phrases because the time-stretch function preserves the frequency of the signal. As a result, it was possible to increase or decrease the length of the sentences without modifying the signal frequency as shown in Table 2. Each phrase was adjusted to duration of 1.2 seconds to ensure that phrases could not be identified based on varying lengths.

Table 2. Translated Phrases, List of Objects used During Testing, and Initial Duration of Each Phrase Before They were Adjusted to 1.2 seconds

Phrases	List of objects	Duration (seconds)
01 – Segure a mão	--------	1.00
02 – Escove os dentes	Toothbrush	1.06
03 – Toque a barriga	---------	1.00
04 – Limpe a Boca	Face towel	1.00
05 – Aperte o Nariz	---------	1.09
06 – Bata os pés	--------	1.06
07 – Penteie o cabelo	Hair brush	1.04
08 – Esconda o rosto	-----------	1.20
09 – Mostre o sapato	----------	1.10
10 – Bata na perna	----------	1.09
11 – Mexa o braço	----------	1.20
12 – Puxe o dedão do pé	----------	1.15

Noise Stimulus

The noise used in this study was the noise stimuli used in the Fidêncio (2013) study, which was a recording of noise in four elementary-school classrooms during normal class period thru the use of a Sony portable digital recorder (Model ICD-BX800). Samples obtained in the four classrooms were edited using the aforementioned audio editing software to remove the amplitude modulation between the recordings (i.e., silent periods) while maintaining the spectral characteristics of noise. Samples from each classroom were merged into one, four-minute wave file. This waveform was, then, edited by using compression and expansion coefficient of 5:1 with a threshold of -15 dBFS to decrease the difference between the maximum and minimum RMS in the whole sample.

This final noise sample was a duration of 3.2 seconds with a difference of 1.2 dB between the maximum and the minimum RMS, -9.7 and -10.9 dB, respectively, in a 50msec time window (Pro Tools HDX 10.3.5). According to Schafer (2005), it is necessary to manipulate the noise to generate a consistent noise, necessary for measuring speech recognition thresholds. Large intensity variations may cause an increase in performance variability within the experimental conditions.

Intensity-Adjustment procedures

A procedure to adjust the intensity of the speech and noise was conducted to ensure equal intelligibility of the phrases; procedures used mirrored the methodology used by Schafer et al. (2012). The edited speech and noise stimuli were recorded on a CD and presented to the 10 adults with normal hearing sensitivity to determine an ascending threshold for each phrase while noise was presented at 60 dBA. An ascending-intensity-scaling process was used for this procedure. The mean difference between the mean threshold for each phrases was subtracted from the mean threshold for all phrases combined. This resulted in the final level presentation level:

Mean threshold of each phrase - Mean threshold of all phrases = Final level of presentation of the Phrases.

Following the scaling process, the examiners excluded two phrases, "Esconda o rosto" (Hide the face) and "Puxe o dedão do pé" (Pull the big toe) because the mean thresholds were +3-dB higher than the remaining phrases. The mean differences of the remaining phrases ranged from -2.9 and 2.1 dB relative to the mean for all phrases combined (Table 3). Therefore, the final version of the PINT Brazil test has 10 phrases with an 8-second inter-stimulus interval that are presented at a fixed intensity (60 dB SPL). The multiclassroom noise ranges in intensity from 45 to 72 dB SPL in 3 dB step sizes.

Table 3. Calculation of the final level of presentation of sentences

Phrases	Final Level of presentation
01 – Segure a mão	2.1
02 – Escove os dentes	- 1.3
03 – Toque a barriga	- 0.3
04 – Limpe a Boca	- 1.3
05 – Aperte o Nariz	- 1.0
06 – Bata os pés	- 0.1
07 – Penteie o cabelo	- 1.5
08 – Esconda o rosto	3.1
09 – Mostre o sapato	- 2.9
10 – Bata na perna	- 2,6
11 – Mexa o braço	- 2.0
12 – Puxe o dedão do pé	7.3

Sentence Lists

Once the intelligibility was verified, six lists of sentences were created with the 10 phrases; each phrase was repeated twice per list in a pseudorandomized manner. In each list of the PINT Brazil, phrases were presented (60 dBSPL). The intensity of the noise increased automatically (recorded on CD) in 3-dB steps for each phrase for the 10 consecutive steps of the descending side, and decreased in 3-dB steps for each phrase for the 10 consecutive steps of the ascending side. This descending and ascending stimuli correspond to the two sides of the score sheet where the examiner notes the accuracy of the response as shown in the same in Figure 2. Each list of the PINT Brazil that was presented had an average duration of three minutes, and participants completed a total of 4 lists.

Figure 2. Sample scoring form for the PINT Brazil

PINT
Brasil

NOME: ______

IDADE: ______ RESPONSÁVEL: ______

DATA: ___/___/___

DISPOSITIVO: ______ FM: ______

D.A: ______

RESULTADOS: (+6)+ (-3) / 2 = +1,5dBSR

LISTA 4 - FALA 0°/ RUIDO 180°

Nº	S/R	FRASES	RESPOSTA	Nº	S/R	FRASES	RESPOSTA
1	+15	Bata os pés	+	11	-12	Toque a barriga	-
2	+12	Penteie o cabelo	+	12	-9	Aperte o nariz	-
3	+9	Bata na perna	+	13	-6	Mostre o sapato	-
4	+6	Segure a mão	+	14	-3	Mexa o braço	+
5	+3	Toque a barriga	-	15	0	Penteie o cabelo	+
6	0	Limpe a boca	-	16	+3	Segure a mão	+
7	-3	Mostre o sapato	-	17	+6	Bata os pés	
8	-6	Mexa o braço	-	18	+9	Limpe a boca	
9	-9	Escove os dentes	-	19	+12	Escove os dentes	
10	-12	Aperte o nariz	-	20	+15	Bata na perna	

Santos, L.G. Phrases in noise test (PINT): Adaptação cultural para o Português Brasileiro e aplicabilidade na avaliação do Sistema de Frequencia Modulada (FM) [dissertação] Bauru (SP): Faculdade de Odontologia de Bauru, Universidade de São Paulo; 2015.

FOB USP

Verification and validity of the lists

In order to verify and examine whether there was equal intelligibility and the possibility of a learning effect for children, 10 children with normal hearing sensitivity were tested. Three male children opted to complete the test by pointing to their own body parts.

Before starting the tests, children were familiarized with the test phrases by being shown how to act out each phrase with a doll. Children were allowed to verbally repeat the sentence and demonstrate the phrases on the doll (e.g., Segure a mão) or just demonstrate with the doll and no verbal response. Afterwards, each randomly-selected list (with no repeats) of sentences were presented through the loudspeakers in the following conditions: (a) one list in quiet, (b) one list at a +15 dB SNR and (c) two randomized lists of the PINT test with prerecorded SNRs. The purpose of the first two conditions was to ensure that the child could demonstrate 100% correct understanding of the phrases when presented in quiet and at a +15 dB SNR. Next, children completed the actual test conditions, which included two lists of PINT in the S0/N180 condition. Children were asked to act out what was heard with the doll.

Scoring rules were determined in previous studies, and this scoring technique is expected to yield 50% correct speech-in-noise thresholds (Schafer, 2005; Schafer &Thibodeau, 2006). As shown in the sample score sheet in Figure 2, the test was suspended when the child obtained three consecutive correct answers of the ascending side of the answer sheet. The threshold in dB SNR was determined by the mean of the following scores: (1) descending side: the last correct answer followed by two incorrect answers (indicated with a circle) and (2) ascending side: the first correct answer followed by two other consecutive correct answers. If the child did not present three consecutive correct answers, the value of +15 dB SNR was considered as the threshold on the ascending side of the scoring form. In the case of 100% correct answers for all tested phrases, the threshold was recorded as -12 dB SNR. A hypothetical speech-recognition score sheet is presented in Figure 2 with a "+" symbol to represent correct responses and a "-" symbol to represent incorrect responses. The child in this example had a threshold of +1.5 dB SNR.

Statistical Analysis

The paired t-test was used to examine list equivalency or the possibility for a learning effect between the lists of the PINT Brazil test. A confidence interval of 95% was adopted. The Pearson Correlation was also used to examine the relationship between PINT performance and the age of the children with normal hearing sensitivity as well as between the PINT Brazil and another test that yields 50% of the thresholds in noise (i.e., HINT/ Brazil, Jacob et al., 2011). On the HINT/Brazil the dB SNR was determined by averaging performance across two lists.

RESULTS

Verification of the PINT Brazil Lists

The PINT Brazil was used to test 10 children with normal hearing sensitivity. On the practice lists, all children were able to repeat the phrases in quiet and at a +15 SNR with 100% accuracy. When comparing the results on the two conditions with the PINT Brazil, there was no significant difference, suggesting no learning effect or measureable difference in performance between lists, $t(9)=1.63$, $p = 0.13$ (Table 4). The average PINT Brazil threshold (i.e., between the two lists) was not correlated with age, $r(10) = -0.1$, $p= .77$.

Table 4. Individual results on the two PINT Brazil lists

Children	List 1 (dBSR)	List 2 (dBSR)	Average SNR	SD (dB)
1	- 4.5	- 7.5	-6.0	2.1
2	- 4.5	- 9.0	- 6.75	3.2
3	- 6.0	- 3.0	- 4.5	2.1
4	- 6.0	- 7.5	-6.75	1.1
5	- 6.0	- 3.0	-4.5	2.1
6	- 4.5	- 6.0	-5.25	1.1
7	- 7.5	- 7.5	- 7.5	0
8	- 6.0	- 6.0	- 6.0	0
9	- 4.5	- 12.0	- 8.25	5.3
10	+ 1.5	- 10.5	- 4.5	8.3
Average	-4.8	-7.2	-6.0	2.5
SD	2.4	2.9	1.3	2.6

When comparing the adult results to those from Schafer (2005) for the intensity-adjustment procedures, the variability between data sets is comparable. For 10 adults in the Schafer study, the variability of 4.4 to 1.8 dB is similar to that of the PINT Brazil study showing 4.9 to 2.0 dB of variation (Table 5).

Table 5. Comparative studies with PINT Schafer (2005) and this study (PINT Brazil) of Signal-to-Noise Ratio (SNR) Performance, Ascending-Phrase Procedure

Phrase	Average SNR PINT – Schafer (2005)	Average SNR PINT Brazil	SD (dB) PINT - Schafer (2005)	SD (dB) PINT Brazil
Hold his Hand	--	-1.4	--	4.4
Brush his teeth	-12.4	-4.8	2.5	2.1
Touch his tongue	-9.6	-3.8	1.8	2.0
Wipe his mouth	-11.0	-4.8	2.2	4.0
Blow his nose	-14.1	-4.5	3.8	3.2
Stomp his feet	-9.1	-3.6	2.2	3.5
Comb his hair	-12.0	-5	3.7	4.9
Hide his face	-12.3	--	2.9	--
Find his shoe	--	-6.4	--	3.6
Bend his leg	-13.0	-6.1	2.7	2.3
Move his arm	--	-5.5	--	3.9
Pull his toes	-13.3	--	4.4	--
Scratch his chin	-9.4	--	1.8	--

Validity of the PINT Brazil lists

The data from the 10 children with normal hearing sensitivity supports the presence of convergent validity, which is the similarity to another measure (Pasquali, 2007; Schafer et al., 2012). To examine this, data from the present study were compared to the data from a HINT/ Brazil condition. No significant difference was found in the results ($t(29)=0.25$, $p=0.80$). It is worth noting that, despite being two distinct normal hearing populations (the population in this study and the population in the study by Jacob et al. (2011), the outcomes were similar.

DISCUSSION

The purpose of this study was to develop a test of speech perception in noise for children from the age of four years through the translation and cross-cultural adaptation of the PINT. The recording of the phrases of the PINT Brazil was carried out by a female talker because studies demonstrate that the speech of this gender is significantly clearer than the speech of a male (Bryne et al., 1994; Bradlow & Bent, 2002; Bradlow et al.,2003).

The test arrangement for the PINT Brazil was designed to simulate a classroom setting where it is assumed that the teacher, the main sound source, stays primarily in the front of the class, and the competitive noise of the classroom is more intense at the side and behind the student. (AAA, 2008, 2011). This test arrangement is similar to those used in previous studies on the assessment of speech perception in noise that used the position S0/N180 and verified a significant improvement of the speech perception compared to the condition S0/N0 (Mok et al., 2010; Van Deun et al., 2010; Jacob et al., 2012; Vicent et al., 2012).

It is worth mentioning that the PINT (Schafer, 2005, Schafer & Thibodeau, 2006) originally was designed to present the speech signal at a 0-degree azimuth and the noise located at 135-degree and 225-degree azimuth relative to the child. However, in 2012, Schafer et al. altered the location of the loudspeakers to S0/N90 and S0/N180. According to the authors, the S0/N180 test position was used to simulate a common arrangement in the classroom with the teacher at the front of the classroom and children behind. This condition was also used to minimize the number of necessary test conditions for children given their short attention times. The two conditions with spatial separation (± 90-degree noise) were used to address the differences between the ears and could be used in the child's actual classroom, in future studies, in the clinic. However, the S0/N180 loudspeaker arrangement will be most appropriate for future research or clinical testing with children using unilateral or bilateral hearing aids with directional microphones, unilateral or bilateral cochlear implants with directional microphones, and FM systems.

The phrase stimuli for the original PINT (Schafer, 2005) were related to body parts and contained five syllables. To translate into Brazilian Portuguese, it was not possible for the sentences to have the same number of syllables because of the differences between the languages, but the results at Table 5 shows no difference in scores.

Verification and Validity of the Pint Brazil lists

When examining list equivalency or the possibility of a learning effect, no learning effect was found. That is, no significant difference was found between the lists, which is similar to findings in other studies (Schafer, 2005; Schafer& Thibodeau, 2006, Schafer et al., 2012). These results are likely due to the familiarity of the stimuli and the practice lists that were completing before the test conditions on the PINT Brazil. It is important to note that there was the risk of children correctly responding to a stimulus by only hearing one of the words of the phrase. However, the children were oriented to listen, understand, and repeat the whole phrase before performing the proposed action. This active response likely engages higher cognitive learning, auditory memory and understanding when compared to other tests that only require the child to repeat what they heard. These types of activities are common is schools in which children are constantly encouraged to follow the teacher´s instructions (Schafer et al., 2012).

Based on the Pearson Correlation results, there was no observable influence of age on the performance of the PINT Brazil lists in the S0/N180 condition, which is similar to results found in other studies that assessed speech perception in noise (Cameron & Dillon, 2007; Garadat & Litovsky, 2007; Nishi et al., 2010). However, these results do not support findings by Schafer et al. (2012), in which younger children (three and four years old) obtained a lower performance compared to older children (from the age of five years) and to adults in both the S0/N180 and S0/N0 test conditions. Similar to Schafer et al., Jacob et al. (2011) found age differences in a S0/N0 condition in three to five-year-old children relative to older children.

In summary, the PINT Brazil can be easily administered by audiologists; it has a relatively short duration; and it requires needs only a two channel audiometer, loudspeakers, dolls and low cost accessories. The use of classroom noise over multi-talker babble or other noises also adds ecological validity to the stimuli because children are asked to listen in classrooms a large portion of their lives. Other tests, such as the HINT/ Brazil (Bevilacqua et al., 2008), are not adapted for children, and few caring centers can purchase the HINT/Brazil due to the high cost and limited availability.

A limitation of the test is that is possible that the participant could identify a particular stimulus by just hearing one word and that, because of this, the test may overestimate speech perception in noise (i.e., the children may perform worse in real environments). It is also important to acknowledge that this study included a relatively small number of participants. Future research should replicate the findings of this study with a larger sample as well as children with hearing loss while using their various technologies (i.e., hearing aids alone; hearing aids with FM system). However, the results of this study provide initial data to which children with hearing loss can be compared. Poorer performance of children with hearing loss would indicate the need for classroom accommodations or a FM system.

Conclusion

The PINT was translated, adapted and validated into Brazilian Portuguese and named PINT Brazil. The results indicate that this test is efficient and sensitive for evaluating speech perception in noise in children, from the age of four years.

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References

American Academy of Audiology [AAA]. (2008 and updated 2011). *Clinical Practice Guidelines: Remote Microphone Hearing Assistance Technologies for Children and Youth from Birth to 21 Years*.

Atcherson, R.A. (2014). Incorporating wireless frequency-modulated technology into your practice. *Semin Hear*, 35, 239-45.

Bevilacqua, M.C., Banhara, M.R., Costa, E.A, Vignoly, A.B., Alvarenga, K.F. (2008). The brazilian portuguese Hearing In Noise Test (HINT). *Int J Audiol*, 47(6), 364-5.

Bevilacqua, M.C, Teach, E.A (1996). Elaboração de um procedimento de avaliação de percepção de fala em crianças deficientes auditivas profundas a partir de cinco anos de idade. In: Marchesan, I.Q., Zorzi, J.L., Gomes, I.C.D. (ed) *Tópicos em Fonoaudiologia*. São Paulo: Lovise, pp. 411-33.

Bradlow, A.R., Bent, T. (2002). The clear speech effect for non-native listeners. *J Acoust Soc Am*, 112(1), 272-84.

Bradlow, A.R., Kraus, N., Hayes, E. (2003). Speaking clearly for children with learning disabilities: sentence perception in noise. *J. Speech Lang Hear Res*, 46 (1), 80-97.

Brasil. (2013, Maio 07). It entered the frequency modulated system personally FM children and / or youth with hearing impairment in the Unified Health System (UHS) Exec. Order No. 21. Retrieved November 21, 2014, from <http>//bvsms.saude.gov.br/bvs/saudelegis/sctie/2013/port0021_07_05_2013.html.

Bryne, D., Dillon, H., Tran, K. (1994). An international comparison of long-term average speech spectra. *J Acoust Soc Am*, 96 (4), 2108-20.

Cameron, S., Dillon, H. (2007). Development of the Listening in Spatialized Noise Sentences Test (LISN-S). *Ear & Hearing*, 28, 196-211.

Costa, M.J (1998). List sentences in Portuguese: presentation and application strategies in audiology. Santa Maria: Pallotti, pp. 26-36.

Delgado, E.M.C., Bevilacqua, M.C. (1999). Lista de palavras como procedimento de avaliação da percepção dos sons da fala para crianças deficientes auditivas. *Pró-fono*, 11(1), 59-64.

Etymotic Research. (2004). *Bamford-Kowal-Bench Speech in Noise Test*. Elk Grove, IL: Etymotic Research.

Fidêncio, V.L.D. (2013). *Avaliação digital do efeito do ruído sobre a fala: relaçãosinal/ruído*. Doctoral dissertation. Bauru: Faculdade de Odontologia de Bauru, Universidade de São Paulo.

Garadat, S.N., Litovsky, R.Y. (2007). Speech intelligibility in free field: spatial unmasking in preschool children. *J Acoust Soc Am*, 121, 1047-1055.

Geers, Moog. (1990). *Early Speech Perception Test (ESP)*. St . Louis: Central Institute for the Deaf.

Guillemin, F., Bombardier, C., Beaton, D. (1994). Cross- cultural adaptation of health-related quality of life measures: literature review and proposed guidelines. *J Clin Epidemiol*, 46(12), 1417-32.

Hicks, C.B., Tharpe, A.M. (2002). Listening effort and fatigue in school-age children with and without hearing loss. J Speech Hear Res, 45 (3), 573-84.

Jacob, R.T., Monteiro, N.F., Molina, S.V., Bevilacqua, M.C., Lauris, J.R., Moret, A.L. (2011). Percepção da fala em crianças em situação de ruído. *Arquivos Int Otorrinolaringol*, 15(2), 163-7.

Jacob, R.T.S., Queiroz- Zattoni, M. (2011). Sistemas de Frequência modulada. Bevilacqua, Martinez, Balen, Pupo, Reis, Frota (eds.) *Tratado de Audiologia*. São Paulo: Santos; pp.727-41.

Jacob, R.T.S., Bevilacqua, M.C., Molina, S.V., Queiroz, M., Hoshii, L.A., Lauris, J.R.P.,Moret, A.L.M. (2012). Sistema de frequência modulada em crianças com deficiência auditiva: avaliação dos resultados. *Rev Soc Bras Fonoaudiol*, 17 (4), 417-21.

Mok, M., Galvin, K.L., Dowell, R.C., McKay, C.M. (2010). Speech perception benefit for children with a cochlear implant and a hearing aid in opposite ears and children with bilateral cochlear implants. *Audiol Neurotol*, 15, 44-56.

Mulla, I., McCracken, W. (2014). Frequency modulation for preschoolers with hearing loss. *Semin Hear*, 35, 206-16.

Nishi, L., Lewis, D.E., Hoover, B.M. (2010). Children's recognition of American English consonants in noise. *J Acoust Soc Am*, 3177- 3188.

Nilsson, M., Soli, S.D., Gelnett, D.J. (1996). *Development and Norming of a Hearing in Noise Test for Children*. Los Angeles, CA: House Ear Institute.

Orlandi, A.C.L., Bevilacqua, M.C. (1999). Deficiência auditiva profunda nos primeiros anos de vida: procedimento para avaliação da percepção da fala. *Pró-fono*, 10(2), 87-91.

Pasquali, L. (2007). Validade dos Testes Psicológicos: Será Possível Reencontrar o Caminho? *Psic: Teor e Pesq*, 23, 99-107.

Saunders, G.H., Frederick, M.T., Chilsolm, T.H., Silverman, S., Arnold, M., Myers, P. (2014). Use of a frequency-modulated system for veterans with blast exposure, perceived hearing problems, and normal hearing sensitivity. *Semin Hear*, 35, 227-38.

Schafer, E.C (2005). *Improving speech recognition in noise of children with cochlear implants: Contributions of binaural input and FM systems*. Doctoral dissertation. Dallas(Texas): The University of Texas at Dallas.

Schafer, E.C., Thibodeau, L.M. (2006). Speech recognition in noise in children with cochlear implants while listening in bilateral, bimodal, and FM-system arrangements. *Am J Audiol*, 15(2),114-26.

Schafer, E.C., Beeler, S., Ramos, H., Morais, M., Monzingo, J., Algier, K. (2012a). Developmental effects and spatial hearing in young children with normal hearing,sensitivity. *Ear & Hear*, 33 (6), 32-43.

Schafer, E. C., Wolfe, J., Algier, K., Morais, M., Price, S., Monzingo, J., Beeler, S., & Ramos, H. (2012b). Spatial hearing in noise of young children with cochlear implants and hearing aids. *Journal of Educational Audiology,* 18, 38-52. [Tier 3, funded by external grants]

Sperry, J.L., Wiley, T.L., Chial, M.R. (1997). Word recognition performance in various background competitors. *J Am Acad Audiol*, 8(2), 71-80.

Thibodeau, L.M., Schaper, L. (2014). Benefits of digital wireless technology for persons with hearing aids. *Semin Hear*, 35, 168-76.

Thibodeau, L.M., Wallace, S. (2014). Guidelines and standards for wireless techonology forindividuals with hearing loss. *Semin Hear*, 35, 59-67.

Van Deun, L., Van, Wieringen., Wouters, J. (2010). Spatial speech perception benefits in young children with normal hearing and cochlear implants. *Ear & Hear*, 31, 702-13.

Vicent, C., Be´be´, Radafy, E., Vaneecloo, F.M., Ruzza, I., Lautissier et al. (2012). Bilateral cochlear implantation in children: localization and hearing in noise benefits. *Int J Pediatr Otorhinolaryngol*, 76, 858-64.

Weaver, N.J, Wardell, F.N, Martin, F.N (1979). Comparison of tangibly reinforced speech-reception and pure-tone thresholds of mentally retarded children. *Am J Ment Defic*, 83(5): 512-7.

The Effect of Multiple Recesses on Listening Effort: A Preliminary Study

Emily Lund, PhD
Texas Christian University

Danielle Brimo, PhD, CCC-SLP
Texas Christian University

Deborah Rhea, EdD
Texas Christian University

Alexander Rivchun, MS
Texas Christian University

Purpose: **This study investigates the relation between a multiple-recess intervention and change in listening effort in early elementary-aged students at the beginning and end of the school day. Method: Kindergarten and first-grade (n = 167) students participating in a larger study, the LiiNK™ project, completed a dual task paradigm designed to measure listening effort via reaction time in the morning and afternoon of a school day. Students attended either an intervention school, participating in four 15-minute recess periods during the school day, or a control school, participating in one 15-minute recess period, usually at the end of the day. Change in reaction time from morning to afternoon was compared across groups. Results: Children in the intervention schools, on average, demonstrated decreased listening effort in the afternoon, as measured by the secondary task, whereas children in the control schools demonstrated increased listening effort. Differences between groups were not the result of between-district differences and did not change from the fall to the spring semester. Conclusion: Preliminary evidence indicates that unstructured play, in the form of multiple recesses during the day, may decrease listening effort in elementary-aged children with normal hearing. Future work should consider how a decrease in listening effort could lead to increased academic learning, particularly in the afternoon.**

Introduction

Despite recommendations from the Society of Health and Physical Educators (SHAPE America) that children receive at least 20 minutes of recess daily in the school setting, scheduling of unstructured play continues to decline in the United States (Murray & Ramstetter, 2013; SHAPE America, 2016). State lawmakers and school personnel have been minimizing unstructured, outdoor play that can strengthen academic scores in order to provide more direct instruction (Pelligrini & Bohn-Gettler, 2013; RWJF, 2013). The removal or minimization of recess in a daily school schedule has had unintended negative consequences not only on physical fitness (CDC, 2011; 2014) but also on cognitive skill development (Biddle & Asare, 2011; Ickes, Erwin, & Beighle, 2013; Verburgh, Konigs, Scherder, & Oosterlaan, 2013).

Play contributes to learning in elementary school aged children (pre-K through grade 5; Piaget, 1965; 1983; Vygotsky, 1967). Unstructured play prompts changes to the behavior in ways that promote cognitive understanding (e.g., paying attention) through interactive, manipulative experiences (Barros, Silver, & Stein, 2009; Pelligrini & Bohn-Gettler, 2013). Students who engage in extended listening activities throughout the day without breaks may experience an increase in listening effort, the cognitive resources required to perceive and process the speech signal, as the day goes on (e.g., Hicks & Tharpe, 2002). Increased listening effort may lead to decreased learning as the day goes on. Although there is a link between attention, memory and learning (e.g., Baddeley, 2003; Cowan, Elliott, Saults, Morey, Mattox, Hismajtullina, et al., 2005), listening effort may represent an additional construct that should be considered in classroom learning. The purpose of this preliminary study was to consider the effects of a multiple recess intervention on kindergarten and first grade students' listening effort throughout the day.

Physical Activity and Learning

Regular physical activity leads to better mental acuity, including brain development (Biddle & Asare, 2011; Verburgh et al., 2013). Neurological research has shown consistently that regular physical activity increases oxygen flow to the brain (Ickes et al., 2013; Ratey, 2013; Verburgh et al., 2013) and increases production of neurotrophins, which stimulates the development of beneficial new neural pathways (Medina, 2008).

Physical activity helps memory and thinking through both direct and indirect means (Hillman, Pontifex, Raine, Castelli, Hall, et al., 2009; Tomporowski, Davis, Miller, & Naglieri, 2008). The benefits of exercise come directly from its ability to reduce insulin resistance, reduce inflammation, and stimulate the release of growth factors—chemicals in the brain that affect the health of brain cells, the growth of new blood vessels in the brain, and even the abundance and survival of new brain cells. Indirectly, physical activity improves mood and sleep, and reduces stress and anxiety. Problems in these areas frequently cause or contribute to cognitive impairment.

Among children, unstructured play prompts changes in the prefrontal cortex, the critical region of the brain's executive control center, responsible for regulating emotions, making plans, and solving problems (Barros et al., 2009; Medina, 2008; Pellegrini & Bohn-Gettler, 2013). This not only moves children along the path toward normal social development, it makes them better thinkers and therefore better learners (Ickes et al., 2013; Subramanian, Sharma, Arunachalam, Radhakrishnan, & Ramamurthy, 2015). Research shows that given 15 minutes of unstructured play, children will spend a third of this time engaged in spatial, mathematical, and architectural activities (Ness, & Farenga, 2016).

When physical activity and recess are performed outside, studies have shown the elements of nature and daylight can additionally enhance the quality of the classroom performance (Biddle & Asare, 2011; Louv, 2008; Medina, 2008; Verburgh et al., 2013). The brain was designed to set the timing of circadian rhythms from extensive exposure to daylight (Medina, 2008). When individuals remain inside for extended periods of time, circadian rhythms lose their timing, leading to abnormal sleep patterns. Exposure to daylight also improves the immune system through the natural absorption of the D3 hormone (Louv, 2008). Natural sunlight can also improve eye health and stress levels (Ratey, 2013). Overall, these different components of health have shown a strong relationship with longer attentional focus, improved reading skills, and verbal fluency (Pellegrini & Bohn-Gettler, 2013; Ratey, 2013; Pettersen, 2016; Tomporowski et al., 2008).

Attention, Memory and Learning

If recess serves to increase a student's ability to sustain attention and learning in the classroom, then the ability to attend throughout the day may be improved by offering multiple recesses daily. At a minimum, a child must attend to new information process and store it (i.e., to learn new information; e.g., Baddeley, 2003; Cowan, Elliott, Saults, Morey, Mattox, Hismajtullina, et al., 2005). According to Baddeley (1996), the central executive, also termed working-memory, is the system responsible for controlling attention. Therefore, the central executive plays an important role in academic learning. For example, tasks thought to measure central executive performance, such as sentence span and auditory digit sequencing tasks, significantly contribute to reading comprehension and word-level reading of 4th and 9th grade students (Swanson & Howell, 2001).

The central executive is a limited-capacity system. If information cannot be held and integrated in the central executive, as when attention resources are diminished, information will be lost and successful learning will not occur (Cowan et al., 2005). In other words, there is a limited amount of processing a person can engage in at a given time, and the cognitive resources, including attention and working memory, available to an individual person will affect the amount he or she can learn.

In a classroom, children must perceive, store, and interpret the speech signal produced by the teacher. Listening effort, or the cognitive resources required to perceive and process the speech signal, represents a construct that could explain a relation between attentional control/resources and learning (e.g., Picou & Ricketts, 2014; Hornsby, 2013; Hua, Karlsson, Widen, Moller, & Lyxell, 2013). If a child is experiencing a high level of listening effort (e.g., having to use a greater proportion of attention resources to perceive and store a speech signal), he or she may have difficulty learning new or complex information. Most researchers have measured the association between learning and skills associated with the central executive with tasks such as sentence span and digit sequencing; however, it is possible that measuring children's listening effort also provides information about children's attention and learning.

Increasingly, researchers are linking listening effort with listening fatigue (e.g., Hornsby, 2013; Hicks & Tharpe, 2002). Fatigue associated with listening may decrease one's ability to attend to or concentrate on new material (e.g., Kennedy, 1988; Leavitt & DeLuca, 2010). Evidence from adults and children with hearing loss indicates that sustained speech processing can lead to increased mental fatigue (Hornsby, 2013, Hornsby, Werfel, Camarata & Bess, 2014; Werfel & Hendricks, 2016). Although listening fatigue has not been fully explored, it is important to consider that fatigue could be an effect of sustained listening effort throughout the school day. If recess allows a child to diminish fatigue as a result of sustained listening, it is possible that children will learn more in the classroom.

Measuring Listening Fatigue

Dual-task paradigms have been used successfully by many researchers to measure listening effort, (e.g., Downs, 1982; Hicks & Tharpe, 2002; Howard, Munro, & Plack, 2010; Rakerd, Seltz, & Whearty, 1996; Sarampolis, Kalluri, Edwards, & Hafter, 2009). These tasks require a listener to simultaneously complete two tasks: a primary task and a secondary task (Feuerstein, 1992). The primary task, a listening and speech-processing task, places increasing demand on a participant's cognitive resources (in a way that could mirror classroom learning). The secondary task, in this case, a reaction-time task, measures any remaining cognitive resources available to the participant. Thus, changes in secondary task performance are indicative of changes in cognitive resources (i.e., changes in listening effort).

Multiple studies have successfully used reaction time in a secondary task to measure the listening effort of adults with and without normal hearing (Sarampalis et al., 2009; Fraser, Gagne, Alepins, & Dubois, 2010; Picou & Ricketts, 2014). Listening effort has also been successfully measured in children. Hicks and Tharpe (2002) measured the reaction time performance of 28 children with and without hearing loss using a primary speech-recognition in background noise task and determined that children with hearing loss expended more effort listening than children with normal hearing. Howard, Munro and Plack (2010) measured reaction time performance of 31 children with normal hearing and determined that, as background noise level increased, secondary task performance decreased. This finding indicated that a dual-task paradigm can be sensitive to changes in listening effort, even in children.

If elementary school children participate in sustained periods of academic instruction without breaks (e.g., recess), it would be reasonable to assume that those children expend increasing amounts of listening effort as the day goes on. Thus, increased academic instruction without breaks may have diminishing returns: as listening effort increases, children may have fewer resources, such as attention, available to them to learn. On the other hand, if children experience frequent breaks throughout the day, it is possible they do not expend as much listening effort during afternoon instruction. The goal of this preliminary study was to determine if participation in frequent physical activity decreased listening effort at the end of the school day. This study represents the first step in a line of inquiry to determine if recess could enhance learning in the classroom by decreasing overall fatigue experienced by students as a result of sustained academic instruction.

This preliminary research study addressed the following question: Do children who participate in more recesses throughout the day demonstrate a faster reaction time performance in a dual task paradigm than children who participate in fewer recesses?

METHODS

Participants

Participants from this study are part of the larger LiiNK™ Project. The LiiNK™ Project includes a teacher and administrator training to implement a character development curriculum called Positive Action® (2007) and to increase the amount of time allotted for unstructured, outdoor play (Rhea, Rivchun, & Pennings, 2016; Rhea, 2016).

For the current study, a stratified random sample of students was selected from two intervention and two control schools matched for district and socioeconomic status distribution. Two males and two females were randomly selected from 43 Kindergarten and 1st grade classrooms totaling 172 students per grade across each school each semester. Teachers were given the opportunity to identify any students that were considered unable to receive English instruction or had a learning disability. Also accounting for absences and inability to participate in the task, 270 total students were asked to participate in the dual-task paradigm (fall and spring). Students who were unable to complete the practice experimental task (described below), students who did not complete all reaction time trials, and students who did not complete the task in the morning and the afternoon of the same day were excluded from analysis. Following removal of students from that original pool, data was taken from a total of 163 students. Data from the North Texas intervention schools and control schools represented a range of socio-economic statuses as indicated in Table 1.

LiiNK™ Project Intervention

In this study, students in intervention schools (n = 88 across both districts) participated in the character development curriculum and in unstructured outdoor play. The amount of time allotted during the school day for unstructured, outdoor play included four, 15-minute recesses throughout the day, totaling 60 minutes each day. Adherence to the outdoor play schedule was monitored by a weekly self-report electronic survey that was sent to the teachers. LiiNK team members also completed visits to the schools to confirm that the teachers were adhering to the LiiNK program. Overall recess adherence was .94, meaning that 94% of scheduled (four 15-minute recesses daily) recess times were attended. The control schools maintained their original school day schedule. For the control schools, the daily schedule consisted of one 15 to 20 minute recess daily.

Experimental Task

To measure listening effort in this project, a dual-task listening paradigm where students simultaneously completed a primary task and a secondary task was created based on the task described by Hicks and Tharpe (2002). The primary attention task speech-recognition stimuli consisted of number series from the Memory for Digits subtest of the Comprehensive Test of Phonological Processing- Second Edition (Wagner, Torgesen, Rashotte, & Pearson, 2013). This subtest measures a participant's ability to repeat increasingly long strings of numbers accurately, and has been validated for use with Kindergarten and first-grade children. Because this project was designed to measure changes in listening effort over time, signal-to-noise ratio was not manipulated in the primary attention task – all children performed this task in quiet.

The secondary attention task consisted of a reaction-time task wherein participants were asked to push an arrow key corresponding to a right or left facing arrow that appeared on a laptop computer screen. Stimuli for the secondary task were designed and controlled by the E-Prime 2.0 software program (Psychology Software Tools, 2012). Arrows appeared in a randomized order at pre-set, at variable time intervals. Participants were instructed to push the correct corresponding arrow as fast as possible when it appeared on the screen.

The timing of the primary and secondary task variables was not consistent across children because the child's responses to the reaction-time task dictated how quickly he or she moved through the task. Thus, if a child reacted very quickly, he or she would

Table 1. LiiNK Cohort 1 Campus Demographics

Campus	Number of Students	% Hispanic	% African American	% White	% Other Ethnicity	% Economic Disadvantaged	% Special Education	% ELL
District 1								
Intervention	879	55.1%	26.1%	6.8%	12.0%	83.6%	6.8%	47.1%
Control	793	41.1%	41.9%	8.3%	8.7%	78.9%	6.8%	32.4%
District 2								
Intervention	593	13.2%	2.6%	81.5%	2.7%	28.4%	7.7%	1.1%
Control	676	26.5%	5.9%	59.5%	8.1%	24.2%	11.6%	5.8%

Source: School District One 2013-2014 report. Texas Academic Performance Report 2013-2014 School District Two complete fewer trials of the primary task. Presentation of the primary task stimuli therefore corresponded to the reaction time trials at varying intervals (sometimes presented at the beginning of a reaction time trial, sometimes in the middle, sometimes at the end).

Procedures

Participants in this study completed the experimental task twice during one school day in the fall and one school day in the spring. Within each day, students in the control and intervention groups completed the task at the beginning of the school day prior to any participation in recess (at the very beginning of the school day) and in the afternoon after several recesses for students in the intervention group or after at least one recess for the students in the control group. Prior to beginning the experimental task, participants were introduced to both tasks and given the chance to practice the primary and secondary task for 20 reaction time trials and 5 number lists (simultaneously). Children who demonstrated understanding of the task were invited to continue the experimental task. Participants were told that accurately repeating numbers was the main task they should focus on, and that the examiner would show the participant his or her scores on the number task when the participant was finished.

In the experimental task, children completed 60 reaction-time trials in the secondary task and as many trials in the primary tasks as possible in the time taken to complete the secondary task. An examiner recorded the child's primary-task responses on-line. Secondary task reaction-time responses were recorded by E-Prime 2.0 software, measured as the time between the appearance of the arrow stimulus and hitting the correct corresponding button.

Analysis

For purposes of analysis, primary task responses were maintained but not used as a measure of listening effort, consistent with other studies of listening effort (e.g., Hicks & Tharpe, 2002). Secondary task responses that were correct (i.e., the correct corresponding button was selected) were measured and reaction times were averaged within each child (i.e., an average reaction time was recorded in the morning and again in the afternoon for each child). Any child who was unable to obtain a correct answer on either the primary or secondary task, or who performed below chance levels on the secondary task was excluded from data analysis.

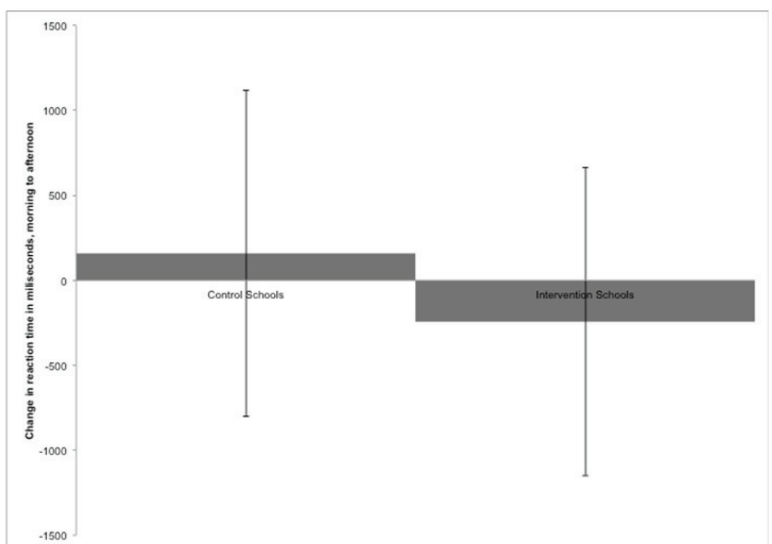
Consistent with other reaction time studies, outlier performances were removed (item by item) from each participant's correct response data pool prior to assessing an individual child's reaction time average. Each participant's performance distribution was consistent with expected distributions (left modal skew of normal distribution) for reaction times. To correct for extreme outlier performance, those data points that were more than 2 standard deviations above each participant's mean and constituted fewer than 5% of the data points for the participant were removed from analysis.

Data were recorded from each kindergarten and first-grade student as reaction time between onset of the stimulus and correct item (arrow direction) selection in both the morning and afternoon testing sessions. The dependent variable, change in reaction time between the first and second session, was calculated for each eligible participant.

RESULTS

Our research question addressed whether children who participated in the LiiNK program would demonstrate a smaller change in morning to afternoon reaction time performance in a dual task paradigm than children not participating in the LiiNK program. Because reaction time data tend to be skewed, parametric statistics were not an appropriate planned analysis. Instead, a nonparametric Mann-Whitney *U* test was applied with change in reaction time from morning to afternoon as the dependent variable and group membership (control or LiiNK intervention school) as the independent variable. The Mann-Whitney *U* test revealed a main effect of group $U = 2048.00$, $Z = -4.079$, $p < .001$ with a mean rank of 95.46 for control schools and 65.31 for intervention schools. This analysis indicated that reaction time changes more for students in the control schools ($M = 159.23$, $SD = 959.48$) than in the intervention schools ($M = -242.422$, $SD = 906.57$). Thus, it appeared that students in control school expended a greater amount of listening effort (as measured by secondary task reaction time) in the afternoon than in the morning. Students in the intervention schools appeared, on average, to complete the task more quickly in the afternoon than in the morning. Thus, these students appeared to expend more effort in the morning than in the afternoon. See Figure 1 for representations of results.

Figure 1. Overall change in reaction time by intervention or control school



Two additional analyses were conducted to ensure the appropriate variables were included in the primary analysis to answer our research question. First, a Mann-Whitney test using district as an independent variable was necessary to rule out pre-existing differences in reaction times between school districts tested. Results indicated no main effect of district $U = 2866.00$, $Z = -1.261$, $p = .207$ with a mean rank for the first district of 76.31 and a mean rank for the second district of 85.66. This finding indicates that school district did not affect our main effect of intervention versus control school (and that the intervention schools followed a similar pattern of performance across districts).

Second, an analysis of performance in fall versus spring was conducted to determine whether longitudinal differences existed in reaction time. The Mann-Whitney test indicated no main effect of semester $U = 2961.00$, $Z = -.940$, $p = .347$ with a mean rank of 78.40 in fall and 85.38 in spring. This indicates that students, whether in control or intervention school, tended to exhibit the same pattern of performance in the fall as in the spring. This would indicate that there are not cumulative effects of daily recess on listening effort throughout the year. The lack of main effects of district and semester confirmed the original analysis, which combined data across districts and across semesters for intervention and control schools.

DISCUSSION

The purpose of this preliminary study was to consider how participation in multiple recesses during the day would change listening effort exerted in the morning versus the afternoon in elementary-school children. Listening effort, as measured by a dual-task paradigm, increased in control schools (who participated in one recess during the day) from morning to afternoon. Conversely, listening effort decreased in intervention schools (who participated in four recesses during the day) from morning to afternoon. These differences in performance did not change in magnitude or direction from fall to spring semesters, and the patterns of performance were similar across the two districts tested. Thus, participation in multiple episodes of unstructured play appeared to influence a child's ability to respond quickly in a secondary reaction time task.

In a dual-task paradigm, reaction time during the secondary task is thought to reflect changes in the cognitive resources available to a student after engaging in a primary speech-perception task (Feurenstein, 1992; Picou & Ricketts, 2014). In this case, the primary speech perception task required a student to perceive a speech signal, understand that signal, and form words (numbers) to repeat back to the examiner. This simple speech perception task should engage a child's auditory attention and auditory working memory, as well as tapping requiring simple verbal skills (i.e., verbal repetition). These skills are necessary for basic communication throughout one's day. If performance on the secondary task does reflect the additional attentional resources available to a student, one could infer that children in control school have fewer additional attentional resources available to them in the afternoon for learning tasks. In other words, children in control schools seemed to be exhibiting increased effort just to listen to a speech signal in the afternoon. Children in intervention schools, on the other hand, actually appeared to have more attentional resources available to them in the afternoon for learning tasks.

Studies have suggested that listening effort may be associated with listening fatigue (Hornsby, 2013; Hicks & Tharpe, 2002). Results of this study fit that idea: it is possible that children who engage in sustained attention activities throughout the day (as children in control schools who participated in extended academic instruction time) experience fatigue as the day goes on. Children in intervention schools, alternatively, were able to break-up engagement in activities involving sustained attention and may have experienced less fatigue. This interpretation is a possible explanation of our results: children who do not participate in recess frequently throughout the day may experience more fatigue (and have access to fewer cognitive resources, such as attention) than children who do participate in recess.

The Baddeley (2003) model that links limited-capacity working memory, attention, and learning provides additional hypotheses about a relation between listening effort and learning in the classroom setting. If children experience limitations on the amount of information that can be processed by their working memories, and must expend more listening effort as the day goes on, one could hypothesize that those children will learn less in the afternoon than in the morning. If we are able to diminish listening effort via intervention (e.g., via recess), then researchers might expect children who participate in the Liink project to exhibit more learning throughout the day than children who participate in a more traditional recess model. This relation between listening effort, attention, working memory and learning needs to be further explored. A link between these skills would have strong implications for recess policies in educational institutions.

The findings of this study, that increased recess in the form of unstructured outdoor play through the day allowed students to exhibit less listening effort in the afternoon, are consistent with other studies describing the benefits of recess. The benefits of physical activity for cognitive processing, including attentional focus, may be reflected in the construct of listening effort. These preliminary findings would indicate that recess is important for more than just physical development, but also for academic growth in the classroom.

Limitations and Future Directions

Findings from this preliminary study provide avenues for future directions. First, there were many students invited to complete the task who were unable to do so. It is possible that altering the parameters of the experimental task (e.g., identifying a less demanding primary task or using a switch button as compared to keyboard keys) would capture the performance of a larger number of students. Future works should explore how the parameters of the dual-task reaction time paradigm affect performance.

Second, there was a large amount of variability in change in reaction time from morning to afternoon across both schools.

This variability is likely the result of many extraneous variables that were not measured in this study. For example, it is possible that some children did not really experience a "break" in attention during recess. Children in some families may have also engaged in sustained attention tasks before school. It is also possible that some children in this sample experienced events during class time or during play that would adversely affect afternoon task performance. A future study may consider the effects of other variables on change in reaction time from morning to afternoon.

Third, individual data on child profiles were not collected. Consequently, it is unclear if children with less obvious learning difficulties, such as language impairment, were included in the sample of children who participated. It is also possible, and perhaps even likely (Bess, Dodd-Murphy, & Parker, 1998), that some children in this sample had minimal hearing loss. Even a very low degree of hearing loss may have affected task performance. Thus, this preliminary data cannot evaluate the effects of child characteristics on reaction time. Future works should more thoroughly define individual participants to identify if some children "need" breaks more than others.

This study represents preliminary findings that participation in multiple recesses throughout the day may decrease listening effort in Kindergarten and first-grade children. Future studies should consider how a decrease in listening effort could directly contribute to increased learning in the classroom. If listening effort decrease is associated with an increase in learning, it is possible that recess contributes academic instruction by shorting quantity of instruction but increasing quality of learning experience.

References

Baddeley, A. (1996). Exploring the central executive. *The Quarterly Journal of Experimental Psychology: Section A, 49*, 5-28.

Baddeley, A. (2003). Working memory and language: An overview. *Journal of communication disorders, 36*, 189-208.

Barros, R. M., Silver, E. J., Stein, R. E. (2009). School recess and group classroom behavior. *Pediatrics, 123*, 431–436.

Bess, F. H., Dodd-Murphy, J., & Parker, R. A. (1998). Children with minimal sensorineural hearing loss: prevalence, educational performance, and functional status. *Ear and Hearing, 19*(5), 339-354.

Biddle, S. J., & Asare, M. (2011). Physical activity and mental health in children and adolescents: a review of reviews. *British Journal of Sports Medicine, 45*, 886–895.

Centers for Disease Control and Prevention (CDC). (2014). *Bridging the Gap Research Program. Strategies for Supporting Recess in Elementary Schools, Update for the 2012 – 13 School Year*. Atlanta, GA: U.S. Department of Health and Human Services.

Centers for Disease Control and Prevention (CDC). (2011). *School Health Guidelines to Promote Healthy Eating and Physical Activity*. MMWR; 60(No. RR-5). Atlanta, GA: U.S. Department of Health and Human Services.

Cowan, N., Elliott, E. M., Saults, J. S., Morey, C. C., Mattox, S., Hismjatullina, A., & Conway, A. R. (2005). On the capacity of attention: Its estimation and its role in working memory and cognitive aptitudes. *Cognitive psychology, 51*, 42-100.

Downs, D. (1982). Effects of hearing aid use on speech discrimination and listening effort. *Journal of Speech and Hearing Disorders, 47*, 189-193.

Feuerstein, J. F. (1992). Monaural versus binaural hearing: Ease of listening, word recognition, and attentional effort. *Ear and Hearing*, 13, 80–86.

Fraser, S., Gagné, J. P., Alepins, M., & Dubois, P. (2010). Evaluating the effort expended to understand speech in noise using a dual-task paradigm: The effects of providing visual speech cues. *Journal of Speech, Language, and Hearing Research, 53*, 18-33.

Hicks, C. B., & Tharpe, A. M. (2002). Listening effort and fatigue in school-age children with and without hearing loss. *Journal of Speech, Language, and Hearing Research, 45*, 573-584.

Hillman, C. H., Pontifex, M. B., Raine, L. B., Castelli, D. M., Hall, E. E., & Kramer, A. F. (2009). The Effect of acute treadmill walking on cognitive control and academic achievement in preadolescent children. *Neuroscience, 159*, 1044-1054.

Hornsby, B. W. (2013). The effects of hearing aid use on listening effort and mental fatigue associated with sustained speech processing demands. *Ear and Hearing, 34*, 523-534.

Hornsby, B. W., Werfel, K., Camarata, S., & Bess, F. H. (2014). Subjective fatigue in children with hearing loss: Some preliminary findings. *American Journal of Audiology, 23*, 129-134.

Howard, C. S., Munro, K. J., & Plack, C. J. (2010). Listening effort at signal-to-noise ratios that are typical of the school classroom. *International Journal of Audiology, 49*, 928-932.

Hua, H., Karlsson, J., Widén, S., Möller, C., & Lyxell, B. (2013). Quality of life, effort and disturbance perceived in noise: A comparison between employees with aided hearing impairment and normal hearing. *International Journal of Audiology, 52*, 642-649.

Ickes, M.J., Erwin, H., & Beighle, A. (2013). Systematic review of recess interventions to increase physical activity. *Journal of Physical Activity & Health, 10*, 910-926.

Kennedy, H. G. (1988). Fatigue and fatigability. *British Journal of Psychiatry, 153*, 1-5.

Leavitt, V. M., & DeLuca, J. (2010). Central fatigue: issues related to cognition, mood and behavior, and psychiatric diagnoses. *PM&R, 2*, 332-337.

Louv, R. (2008). *Last child in the woods: Saving our children from nature-deficit disorder*. Chapel Hill, NC: Algonquin Books of Chapel Hill.

Medina, J. (2014). *Brain rules: 12 principles for surviving and thriving at work, home, and school*, 2nd ed. Pear Press: Seattle, WA.

Murray, R., & Ramstetter, C. (2013). The crucial role of recess in school. *Pediatrics, 131*, 183-188.

Ness, D., & Farenga, S. J. (2016). Blocks, bricks, and planks: Relationships between affordance and visuo-spatial constructive play objects. *American Journal of Play, 8*, 201.

Pellegrini, A. D., & Bohn-Gettler, C. M. (2013). The benefits of recess in primary school. *Scholarpedia, 8*, 30448.

Pettersen, J. A. (2016). Vitamin D and executive functioning: Are higher levels better? *Journal of Clinical and Experimental Neuropsychology, 38*, 467-477.

Piaget, J. (1965). *The moral development of the child*. New York, NY: Free Press.

Piaget, J. (1983). Piaget's theory. In W. Kessen (Ed.), *Handbook of child psychology: History, theory, and methods* (pp. 103-128). New York. Wiley.

Picou, E. M., & Ricketts, T. A. (2014). The effect of changing the secondary task in dual-task paradigms for measuring listening effort. *Ear and Hearing, 35*, 611-622.

Positive Action® Inc. (2007). Positive Action® measures. Twin Falls, ID: Positive Action®, Inc. Retrieved Sept 20, 2008 from http://www.positiveaction.net/support/index.asp?ID1=2&ID2=215.

Psychology Software Tools, Inc. [E-Prime 2.0]. (2012). Retrieved from http://www.pstnet.com.

Rakerd, B., Seitz, P., & Whearty, M. (1996). Assessing the cognitive demands of speech listening for people with hearing losses. *Ear and Hearing, 17*, 97-106.

Ratey, J. J. (2013). *Spark: The revolutionary new science of exercise and the brain*. New York, NY: Little, Brown, & Company.

Rhea, D.J., Rivchun, A.P., & Pennings, J. (2016). The LiiNK Project: Implementation of a Recess and Character Development Pilot Study with Grades K & 1 Children. *Texas Association of Health, Physical Education, Recreation, & Dance Journal (TAHPERD), 84* (2).

Rhea, D.J. (2016). Recess: The forgotten classroom. *Instructional Leader Journal, 29* (1), 2-6.

Robert Wood Johnson Foundation (RWJF, 2013). Childhood Obesity: The Challenge. Retrieved August 2013, from http://www.rwjf.org/en/about-rwjf/program-areas/childhood-obesity/the-challenge.html.

Sarampalis, A., Kalluri, S., Edwards, B., & Hafter, E. (2009). Objective measures of listening effort: Effects of background noise and noise reduction. *Journal of Speech, Language, and Hearing Research, 52*, 1230-1240.

SHAPE America. (2016). Guide for Recess Policy. Reston, VA. Retrieved from: www.shapeamerica.org/advocacy/.../Guide-for-Recess-Policy.pdf.

Subramanian, S.K., Sharma, V.K., Arunachalam, V., Radhakrishnan, K., & Ramamurthy, S. (2015). Effect of structured and unstructured physical activity training on cognitive functions in adolescents - a randomized control trial. *Journal of Clinical & Diagnostic Research, 9*, 4-9.

Swanson, H. L., & Howell, M. (2001). Working memory, short-term memory, and speech rate as predictors of children's reading performance at different ages. *Journal of Educational Psychology, 93*, 720.

Tomporowski, P.D., Davis, C.L., Miller, P.H., & Naglieri, J.A. (2008). Exercise and children's intelligence, cognition, and academic achievement. *Educational Psychology Review, 20*, 111-31.

Verburgh, L., Konigs, M., Scherder, E. J. A., & Oosterlaan, J. (2013). Physical exercise and executive functions in preadolescent children, adolescents and young adults: a meta-analysis. *British Journal of Sports Medicine*. DOI: 10.1136/bjsports-2012-091441.

Vygotsky, L. (1967). Play and its role in the mental development of the child. *Soviet Psychology, 12*, 62-76.

Wagner, R. K., Torgesen, J. K., Rashotte, C. A., & Pearson, N. A. (2013). *Comprehensive test of phonological processing: CTOPP2*. Austin, TX: Pro-Ed.

Werfel, K. L., & Hendricks, A. E. (2016). The relation between child versus parent report of chronic fatigue and language/literacy skills in school-age children with cochlear implants. *Ear and Hearing, 37*, 216-224.

The Role of Sound Field Amplification for English Language Learners

Pam Millett, PhD
York University
Toronto, Canada

Research on sound field amplification has shown positive effects on hearing and speech perception for many students, including English Language Learners. This qualitative study investigated benefits beyond improved speech perception from the perspective of classroom teachers. Unstructured interviews were conducted with 11 elementary teachers who used sound field amplification in their classrooms in a high needs urban school with a high percentage of English Language Learners (ELLs). Using qualitative data analysis procedures, 3 primary themes emerged, describing benefits of sound field systems in Enhancing English Language Learning, Enhancing Teacher Effectiveness, and Enhancing Student Engagement. The key finding related to Enhancing English Language Learning was the role of sound field amplification in enhancing and refining the spoken English language model provided to students, particularly under difficult listening environments. Teachers noted that use of their sound field system allowed them to highlight subtle morphological and syntactic markers in English for which students were unaccustomed to listening in their first language. Teachers also reported innovative uses of the technology to create more dynamic classrooms and improve student engagement.

INTRODUCTION

Anderson (2004) coined the term "learning to listen in a sea of noise" to describe the situation in which children are required to spend a large part of their day engaged in listening under less than optimal acoustic conditions. Noise is a problem for everyone, but some students experience more difficulty than others. These include young children with immature listening skills, students with temporary hearing loss from recurrent ear infections, students with auditory processing, language or learning disabilities, and English Language Learners. Research shows that children are less able than adults to listen and understand effectively in the presence of background noise (Crandell & Bess, 1986, Crandell & Smaldino, 2000; Evanston & Elliott, 1979). Research with children indicates better ability to discriminate words and spoken language more accurately with the use of a sound field amplification system than without (Arnold & Canning, 1999; Sockalingham, Pinard, Cassie & Green, 2007). Studies have found improved scores in dictated spelling tests (Zabel & Taylor, 1993) and better standardized test scores in reading (Millett & Purcell, 2010). A longitudinal study by Gertel, McCarty & Schoff (2004) found that students in amplified classrooms scored 10% better on a standardized achievement test than students in unamplified classrooms. Outcome measures from the Mainstream Amplification Resource Room Study Project (MARRS) indicated better scores on standardized tests of listening and language skills for kindergarten students, and better scores in the areas of math concepts, math computation and reading for grade 2 and 3 students (Ray, 1992). Massie & Dillon (2006) reported statistically significant improvements in ratings of attention, communication and classroom behaviour in amplified classrooms, and noted that teachers considered that "sound-field amplification facilitated peer interaction, increased verbal involvement in classroom discussion, and promoted a more proactive and confident role in classroom discussion" (p. 89). Allcock (1999) found improvements in standardized test scores of phonological processing, with 74% of children in amplified classrooms achieving an improvement of 1 stanine or more, versus 46% in unamplified classrooms (Allcock, 1999). Rubin, Aquino-Russell, & Flagg- Williams (2007), in a study of 60 Canadian classrooms, found statistically significant increases in student responses to teacher statements, decreases in the number of teacher repetitions, and fewer student-initiated communications with peers during instruction (i.e. fewer instances of students speaking amongst themselves during teacher instruction) in the amplified classrooms.

A small body of literature has indicated that understanding spoken language in the presence of background noise is even more problematic for adults and children learning English as a second language (Crandell & Smaldino, 2000; Mayo & Florentine, 1997; Nabelek & Nabelek, 1994; Nelson, Kohnert, Sabur, & Shaw, 2005). Mayo & Florentine (1997) found that children acquiring English at an older age had more difficulty with speech discrimination in noise than younger bilingual children. Nelson at al. (2005) in a study of speech perception in noise by children who were monolingual versus children who were English Language Learners, found that the average decrease in performance accuracy was four times greater for the ELLs than for the children who spoke English only. This difficulty with speech understanding in noise was not postulated to be related to differences in hearing levels between English Language Learners and children with English as a first language. Rather, when individual words or speech sounds are missed because of high levels of background noise, listeners must rely on their knowledge of the language, contextual cues, and metalinguistic and metacognitive strategies to make sense of a distorted or partially missing message. This is a difficult task for a child, who is still learning a new language while expected to be able to access the curriculum in often difficult listening environments.

There are a small number of studies on benefits of sound field amplification for English Language Learners. Sound field amplification has been shown to produce improvements in speech perception scores of up to 30% for children learning English as a second language when noise is present (Crandell, 1996). Vincenty-Luyando (2000) compared monolingual school children and English Language Learners in their speech perception accuracy in a real classroom with typical classroom noise levels introduced, with and without sound field amplification. English Language Learners had significantly poorer phoneme discrimination abilities in the presence of noise (63% vs. 76% for children with English as a first language). Under the highest noise conditions, all children's scores combined improved by 19% with the introduction of sound field amplification. Reel & Hicks (2011) suggested that there may be improvements in auditory selective attention with use of sound field amplification for students exposed to a second language at home.

There is no doubt that the primary benefit of sound field amplification is to make the teacher's voice clearer, more consistent and easily heard by students wherever they are located in a classroom. However, many studies have also reported anecdotal comments or questionnaire responses by teachers which suggest that sound field amplification also impacts less easily quantifiable, but equally important aspects of classroom learning such as teacher effectiveness, classroom management and overall listening skills. These findings include less need to repeat instructions (Dairi, 2000; Edwards, 2005; Rosenberg, Blake-Rahtner, Heavner, Allen, Redmond & Phillips, 1999), better student attention and on-task behaviours (Allen & Patton, 1990; Cornell & Evans, 2001; Dockrell & Shields, 2012), fewer teacher absences due to vocal problems (Allen, 1995), a reduction in vocal effort by teachers (Sapienza, Crandell & Curtis, 1999), and better listening skills (Dowell, 1995; Edwards, 2005; Rosenberg et al., 1999). These studies suggest that sound field amplification may impact more than just speech perception.

Other than a few studies which include anecdotal teacher comments, there is an almost complete lack of research focused on describing the experiences of the primary user of sound field amplification technology, the classroom teacher. The rationale for this study, then, was twofold – through interviews, to explore teacher experiences with sound field amplification, and to explore whether this impact might differ for students who were English Language Learners than for monolingual English speakers.

METHOD

Context

This study took place in a kindergarten to Grade 5 school located in a low income area in a large urban Canadian city. Of the approximately 275 students in the school, 65% were non-native English speakers, 98% had parents who were born outside Canada, and 40% of students had Individualized Education Plans (IEPs). Family income was quite low in many cases, with 37% of families classified as low income families (personal communication, school principal). As a school-based initiative, SMART Board interactive whiteboards interfaced with Front Row Pro D sound field systems had been installed one year previously in 9 grade 1 to 5 classrooms, as well as the library and computer lab (for a total of 11 rooms outfitted). This study took place after approximately one year of sound field system use by teachers. This study was approved through the university Human Participants Research Committee, and consent forms were signed by all participants prior to interviews. Informed consent forms for interviews were signed by teachers, and informed consent forms for hearing screenings of students were signed by parents.

Participants

Unstructured interviews were conducted with 11 teachers of grades 1 to 6. Participants included three kindergarten teachers, one grade 1 teacher, two teachers of split grade 1/ 2 classes (ie a class including both grade 1 and grade 2 students) , one grade 2 teacher, one grade 4 teacher and one grade 6 teacher, as well as the French teacher (who taught French to all students in grades 4, 5 and 6), and the librarian. Each teacher was initially asked an open-ended question "what do you think about your sound field system?"; follow-up questions regarding observations about vocal fatigue or difficulties managing technical aspects were sometimes asked, but generally, teachers required little encouragement or prompting to provide their thoughts. Each interview was conducted in the teacher's own classroom, lasted approximately 20 minutes and was audio taped for later transcription and analysis. The school principal was not interviewed formally, but her comments during meetings and presentations throughout the course of the study were considered as well.

Student hearing screening. At the beginning of the study, hearing screenings were conducted for all students from junior kindergarten to grade 2, using pure tone audiometry (presented at 20 dB for the frequencies 1000, 2000, and 4000 Hz), as well as tympanometry, in accordance with the American Academy of Audiology (2011) guidelines for hearing screening. Due to resource limitations and in consultation with the school principal, the decision was made to focus the hearing screening initiative on younger students. envA second hearing screening was conducted 2 weeks later for students who did not pass the original screening. A total of 120 students received hearing screenings by the researcher, a licensed audiologist. Of the 120 students screened, eight students had a refer result on the first screening, decreasing to six students on the second screening, all with evidence of middle ear dysfunction. Results were conveyed to parents with recommendations for medical follow-up where appropriate.

Teacher Interviews Data Analysis

Analysis of the data was approached from the grounded theory perspective described by Creswell (2009). Creswell describes the methodology as "a strategy of inquiry in which the researcher derives a general, abstract theory of a process, action or interaction grounded in the views of the participants". Interviews were transcribed from audio recordings, and transcripts were read carefully, code words and phrases were identified, and comparisons between subject transcriptions were made. Source codes were attached to each comment to identify the location of data within the transcript. Theme codes were then developed for the data segments. Once themes were identified, category codes were developed so that similar themes could be combined and analyzed together.

RESULTS AND DISCUSSION

As summarized in Table 1, several themes regarding benefits of sound field system use emerged from interview analysis that were surprisingly consistent across teacher interviews. These were given the descriptors “Enhancing English Language Learning”, “Teacher Effectiveness”, and “Enhancing Student Engagement”.

Enhancing English Language Learning

Every teacher with the exception of the librarian commented on the fact that the sound field system allowed them to provide a better spoken English model to their students, and more specifically, enabled the students to hear the subtle phonological differences that result in differences in meaning. This was expressed differently by different teachers, but the core underlying concept seemed to be that English Language Learners needed an English language model that was not just simpler in terms of grammar and vocabulary, but that individual speech sounds and words needed to be acoustically clearer.

Many languages are represented at this school, all of which have different phonological and syntactic features from English. Teachers emphasized that the development of English oral language skills is a key focus for them during all teaching and learning activities. The importance of students being able to hear the teacher’s spoken language model as clearly as possible was highlighted again and again by the teachers in their interviews. The grade 6 teacher noted that when he was teaching geometry, “there’s a big difference between ‘side’ versus ‘size’ in geometry but I have to use both words all the time and without the sound field, sometimes students had misunderstandings about things like that”.

In addition, learning French as a second language is required in Canadian schools. While most teachers referred to the importance of a clear language model for learning English, the French teacher highlighted the challenges inherent in adding the requirement for students to learn French as well. She noted that even for native English speakers, there are confusing differences between English and French. For example, in French, plural nouns are often marked with a final /s/ in print which is silent, but denoted in spoken French by the preceding article (such as the use of “les” instead of “le” or “la” to indicate a plural noun). Nouns are also characterized by gender which is reflected in the articles and adjectives used with them (for example, “intelligent” in its masculine form has a silent final /t/; “intelligente” in its feminine form requires articulating the final /t/). This is not so in English, which does not characterize gender in nouns, and where plurality is frequently indicated by use of an audible final /s/ or /z/ plus auxiliary verb agreement (e.g. “The boy is going home” vs “The boys are going home”). In Spanish, by contrast, the subject of the sentence is generally missing because it is identified by the verb ending (for example, ‘tengo’ meaning ‘I have’ versus ‘tenemos’ meaning ‘we have’). These are confusing and subtle syntactic differences denoted by phonological features between languages with which students are relatively unfamiliar, and which they may be unaccustomed to listening for in their native language. One teacher commented that at this school, in fact, French may represent a third, fourth or fifth language for some students.

Teachers commented many times that the sound field system allowed them to reinforce morphological markers, auxiliary verbs, and other difficult-to-hear aspects of English syntax and to provide a consistent, clear English model. Teachers consistently identified English grammar as being the most problematic for their English Language Learners, primarily because morphological markers vary so widely across spoken languages.

As well as hearing a clearer English model from the teacher, the sound field amplification was also described as providing a better opportunity for students to hear their own, and peers’, pronunciation. For example, one teacher recounted an incident in which she had recorded a guest storyteller through the sound field system, and then allowed the students to play it back to practice their own reading. One student heard for the first time that his articulation of /r/ and /l/ were incorrect, and asked the teacher for help with this.

Teacher Effectiveness

Teachers consistently reported positive effects on vocal health. Several commented on fewer sore throats, stronger voices at the end of the week and generally less vocal strain and overall fatigue; one teacher noted “My throat used to be very sore by Friday”. However, they also noted benefits of the sound field systems to their teaching practices which went beyond simply providing them with stronger and healthier voices. Several commented that they were able to be more dramatic and effective storytellers; they were able to vary their vocal intensity, intonation patterns, and vocal sound effects while reading a story and students could hear these subtle nuances. The principal and several staff members also noted the effectiveness of the sound field system in the library, where the kindergarten through grade 3 students gather during indoor lunch/recess periods in inclement weather. The significant time, energy and vocal effort saved when bringing students in, monitoring behavior and dismissing students was noted in this situation. The minute or two saved in getting students’ attention, or providing an instruction only once instead of multiple times may seem inconsequential as an individual event, but over the course of a day, these minutes add up to significant time devoted to instruction rather than classroom management. One teacher commented “it doesn’t mean that you never have to repeat yourself, but it makes your teaching strategies a lot more effective”. Another teacher noted “I love it. My kindergarten class is noisy, it’s noisy even when they’re working productively and when it’s activity time and it’s time to tidy up, I don’t have to scream and yell to get their attention. It’s wonderful. Story time, even again, when they’re sitting on the carpet, even when they’re quiet, it’s noisy.”

Enhancing Student Engagement

A change consistently noted by teachers and principal was improvements in student engagement. Student engagement is an important topic in education and been shown to be strongly linked to increased academic success and decreased dropout rates (Fredericks, Blumenfeld & Paris, 2004). The explanation offered by both the principal and several teachers was that the SMART Board provided visual engagement, and the sound field system provided auditory engagement. The sound field system was described as providing opportunities for teachers to use audiovisual materials in more interesting and engaging ways for students, and to make classrooms more dynamic learning environments as a result.

The SMART Board, in combination with wireless Internet, allowed access to a variety of interesting materials and activities which would otherwise be difficult or impossible to use, and the sound field system allowed the accompanying audio to be heard clearly and consistently. When the SMART Board was not in use, however, teachers still used the sound field system to add audio to classroom activities in innovative ways. One teacher arranged to have a visiting Aboriginal storyteller work with her students, and audio recorded the story. She then played the recording through the sound field system to allow students to listen to the recording and practice reading the same story, matching her inflections and style. Another teacher, in conjunction with a doctoral student from a nearby university, was engaged in a project where students did interviewing and role-playing, and used the sound field system to replay the audio part of the recording during student editing, to allow them to hear more clearly.

Another teacher played classical music through her iPod during quiet seatwork and Halloween music and sound effects during reading of a Halloween story. She noted that music helps set the tone for a variety of classroom activities, and music is clearer through the sound field system than through her own CD player. Another teacher kept an active link on the SMART Board to an eagle nesting site in British Columbia over the course of 6 weeks so students could monitor the baby eagles both visually and auditorally.

Every teacher mentioned the effectiveness of the passaround microphone in increasing student interest and willingness in speaking in front of the class. A frequent comment was that shy or quiet students were more willing to speak in front of the class when the passaround microphone was available. One teacher commented "I can be dramatic without being loud, it makes them far more engaged. So that's why I like it. The microphone – amazing. I have some very very very quiet children who don't want to speak. When they get that microphone in front of them for show and tell or when they're being one of Five Little Pumpkins, and they're saying their lines, the quiet ones are speaking. It's really really bringing them out."

Another noted that when a student was using the passaround microphone, other students afforded him/her the respect and courtesy of listening. Classroom management is facilitated, since the use of the passaround microphone is a clear signal that a student (and only that student) is speaking, and only upon being handed the microphone, can the next student speak.

Table 1. Summary of Key Findings from Interviews

Theme	Key findings on use of sound field system	Sample teacher comments
Enhancing English language learning	Provides a better quality spoken language model for English Language Learners (ELLs) ELLs are better able to hear subtle syntactical and morphological information which differ in English from their own first language Use of passaround microphone allowed ELLs to hear their own, and peers' pronunciation of English words more clearly	"There's a big difference between 'side' versus 'size' in geometry but I have to use both words all the time and without the sound field, sometimes students had misunderstandings about things like that".
Enhancing teacher effectiveness	Positive effects on teacher vocal health Positive effects on student behavior and classroom management	"It doesn't mean that you never have to repeat yourself, but it makes your teaching strategies a lot more effective"
Enhancing student engagement	Enhances use of audiovisual materials in creative and engaging ways Use of the passaround microphone increases students' interest and willingness in speaking in front of the class	"When they get that microphone in front of them for show and tell or when they're being one of Five Little Pumpkins, and they're saying their lines, the quiet ones are speaking."

CONCLUSIONS

This study found three benefits of sound field amplification that have not been discussed or explored in previous research focused on speech perception and academic outcomes. Teachers clearly described the very specific need for English Language Learners of the provision of clear English phonology. Intuitively, learning a new language is easier when the message is simple, short, clear and uses simple vocabulary and grammar. However, the teachers in this study were also convinced that hearing all of the individual speech sounds and words was critical, since even if the individual speech sounds of English are the same as in one's first language, English uses speech sounds to convey meaning (such as plurality and verb tense) in ways that are different from other languages. This finding is consistent with research by Bradlow & Alexander (2007), found that the speech perception in noise of non-native listeners improved when acoustic enhancement of word final consonants was provided.

Another theme emerging from this study which has not been previously discussed in the literature is changes in student engagement related to sound field system use. The concept of engaged learning is an important one in education, and its relationship to outcome measures such as school dropout rates has been demonstrated (Archambault, Janosz, Fallu & Pagani, 2009). Specific indicators of student engagement have been developed by Jones, Valdez, Nowalski & Rasmussen (1994), which allow educators to create a picture of what engaged learning means in a classroom, and how to evaluate and reinforce it. These indicators of a community of engaged learners emphasize collaborative learning, complex and authentic (i.e. relevant to students) activities, high levels of interaction between students and teachers, and students and peers, and an emphasis on the role of the teacher as collaborator, co-learner and co- investigator, allowing the group to construct knowledge (rather than teacher as disseminator of information). In more recent years, the concept of three types of engagement has emerged. These include behavioral (participation and involvement), emotional (positive and negative reactions to teachers, academics and school), and cognitive (willingness to engage with difficult material) (Jones, Valdez, Nowakowski & Rasmussen, 1995). The use of technology to increase student engagement, particularly for behavioral and cognitive engagement, has begun to be discussed and investigated in recent years. This study suggests that sound field amplification might appropriately be added to this list of engagement-enhancing technologies.

As with any qualitative study, generalization of results can be limited because of the small number of interviewees, and the specific context in which the participants teach. However, teacher comments from a range of grades (junior kindergarten to grade 5) and in a variety of areas (from the librarian to classroom teachers to the French teacher to the special education teacher) were remarkably consistent.

The benefits of sound field amplification for improved hearing and listening for young children and at-risk learners has long been known; however, the results of this study suggests that there may be less tangible but equally important effects for all participants in the classroom community. The staff and students of this school are likely similar to other urban public schools located in areas with high immigrant populations and low average family incomes. They face issues of poverty, the challenges of English as a Second Language (for both parents and students), an extremely multicultural community, new immigrant challenges and an aging school with less than optimal acoustics. The teachers in this study were able to expand the possibilities of sound field amplification to create not just better listening environments, but more dynamic learning environments. The last word on the use of sound field amplification should belong to the school principal "It enables children to acquire language in the best possible way. You acquire a language by hearing it, by engaging in it. If you don't hear it accurately, it is a deficit to the acquisition of it."

REFERENCES

Allcock, J. (1999). Report of FM sound field study, Paremata School, 1997. Oticon Research Draft.

Allen, L. (1995). The effect of sound field amplification on teacher vocal abuse problems. Paper presented at the Educational Audiology Association Conference, Lake Lure, NC.

Allen, L., & Patton, D. (1990). Effects of sound field amplification on students on-task behavior. Paper presented at the American Speech Language Hearing Convention, Seattle, Washington, November.

American Academy of Audiology (2011). Childhood Hearing Screening Guidelines. https://audiology-web.s3.amazonaws.com/migrated/ChildhoodScreeningGuidelines.pdf_5399751c9ec216.42663963.pdf

Anderson, K. (2004). The problem of classroom acoustics: The typical classroom soundscape is a barrier to learning. *Seminars in Hearing, 25*(2), 117–130.

Archambault, I., Janosz, M., Fallu, J-S, & Pagani, L. (2009). Student engagement and its relationship with early high school dropout. *Journal of Adolescence, 32* (3), 651-670.

Arnold, P., & Canning, D. (1999). Does classroom amplification aid comprehension? British Journal of Audiology, 33(3), 171-178.

Bradlow, A. R., & Alexander, J. A. (2007). Semantic and phonetic enhancements for speech-in-noise recognition by native and non-native listeners. *The Journal of the Acoustical Society of America, 121*(4), 2339-2349.

Cornwell, S., & Evans, C. (2001). The effects of sound field amplification on attending behaviors. *Journal of Speech Language Pathology and Audiology, 25*(3), 135- 144.

Crandell, C. (1996). Effects of sound field FM amplification on the speech perception of ESL children. *Educational Audiology Monograph, 4*, 1-5.

Crandell, C., & Bess, F. (1986). Speech recognition of children in a 'typical' classroom setting. *Asha, 29*, 82.

Crandell, C., & Smaldino, J. (2000). Classroom acoustics for children with normal hearing and with hearing impairment. *Language, Speech and Hearing Services in Schools, 31*, 362-70.

Crandell, C., Smaldino, J., & Flexer, C. (1999). An overview of sound-field FM amplification. *The Hearing Review, 6*(6), 40-2.

Creswell, J. (2009). *Research Design (3rd edition)*. London: Sage.

Dairi, B. (2000) Using sound field FM systems to improve literacy scores. *Advance for Speech Language Pathologists and Audiologists, 10*(27), 5, 13.

Dockrell, J. E., & Shield, B. (2012). The impact of sound-field systems on learning and attention in elementary school classrooms. *Journal of Speech, Language, and Hearing Research, 55*(4), 1163-1176.

Dowell, J. (1995). Trial of sound-field amplification system. Proceedings of the Otitis Media NSW Conference 1995-Its Implications for Aboriginal and Torres Strait Islander People. New South Wales Department of Health, New South Wales Department of School Education, New South Wales Board of Studies.

Edwards, D. (2005). A formative evaluation of sound field amplification system across several grade levels in four schools. *Journal of Educational Audiology, 12*, 59- 66.

Evanston, IL. Elliott, L. (1979). Performance of children aged 9 to 17 years on a test of speech intelligibility in noise using sentence material with controlled word predictability. *Journal of the Acoustical Society of America, 66*, 651-653.

Flexer, C. (2000). The startling possibility of sound field. *Advance for Speech Language Pathologists and Audiologists, 10*(36), 5, 13.

Fredericks, J., Blumenfeld, P., & Paris, A. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59-110.

Gertel, S., McCarty, P., & Schoff, L. (2004). High performance schools equals high performing students. *Educational Facility Planner, 39*(3), 20-24.

Jones, B., Valdez, G., Nowakowski, J., & Rasmussen, C. (1995). Plugging in: Choosing and using educational technology. Washington, DC: Council for Educational Research and Development, and North Central Regional Educational Laboratory.

Massie, R., & Dillon, H. (2006). The impact of sound-field amplification in mainstream cross-cultural classrooms: Part 2. Teacher and child opinions. *Australian Journal of Education, 50*(1), 78-95.

Mayo, L., & Florentine, M. (1997). Age of second- language acquisition and perception of speech in noise. *Journal of Speech and Hearing Research, 40*(3), 686-693.

Millett, P., & Purcell, N. (2010). Effect of sound field amplification on grade one reading outcomes. *Canadian Journal of Speech-Language Pathology and Audiology, 34*(1), 17-24.

Nabelek, A., & Nabelek, I. (1994). Room acoustics and speech perception. In J. Katz (Ed.), *Handbook of Clinical Audiology* (4th ed., pp. 624-37). Baltimore, MD: Williams & Wilkins.

Nelson, P., Kohnert, K., Sabur, S., & Shaw, D. (2005). Classroom noise and children learning through a second language: Double jeopardy? *Language, Speech and Hearing Services in Schools, 36*(3), 219-29.

Ray, H. (1992). Summary of Mainstream Amplification Resource Room Study (MARRS) adoption data validated in 1992. Norris City, IL: Wabash and Ohio Special Education District.

Reel, L., & Hicks, C. B. (2011). Development of Selective Auditory Attention: Effects of the Meaning of Competing Speech and Daily Exposure to Soundfield Amplification. *Journal of Educational Audiology, 17*, 36-52.

Rosenberg, G., Blake-Rahtner, P., Heavner, J., Allen, L., Redmond, B., & Phillips (1999). Improving classroom acoustics (IAC): A three-year FM sound-field classroom amplification study. *Journal of Educational Audiology; 7*(3). 8-28.

Rubin, R., Aquino-Russell, & Flagg-Williams (2007). Evaluating sound field amplification technology in New Brunswick Schools. Paper presented at the annual conference of the Canadian Association of Speech- Language Pathologists and Audiologists.

Sapienza, C. M., Crandell, C. C., & Curtis, B. (1999). Effects of sound-field frequency modulation amplification on reducing teachers' sound pressure level in the classroom. *Journal of Voice, 13*(3), 375-381.

Sockalingham, R., Pinard, L., Cassie, R., & Green, W. (2007). Benefits of sound field amplification for elementary school children with and without hearing loss. *Asia Pacific Journal of Speech, Language and Hearing, 10*(3), 145-155.

Vincenty-Luyando, M. (2000). The effect of noise and sound-field FM amplification upon the speech perception abilities of bilingual and monolingual students. PhD dissertation, The University of Connecticut.

Zabel, H., & Taylor, M. (1993). Effects of sound-field amplification on spelling performance of elementary school children. *Educational Audiology Monograph 3*.

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