Reducing Acoustic Barriers in Classrooms: A Report Comparing Two Kindergarten Classrooms in an Inner-City School

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A project was undertaken to demonstrate the effects of sound-field amplification on learning in a low socio-economic urban classroom environment. The results of testing for identifying children who are at risk for academic difficulty as measured by the Preschool S.I.F.T.E.R. and phonological awareness as measured by the TOPA (Kindergarten Version) for two kindergarten classes were compared. Implications of these findings are presented.

Introduction

The classroom environment has a direct effect on how children learn. In addition to adequate lighting, appropriate room temperature, and comfortable seating, it is essential that classrooms have an acceptable noise level.
The auditory-verbal environment in any classroom cannot be ignored because children spend from 45-60% of their day listening to either their teachers or their classmates. (Rosenberg, Blake-Rahter & Heavner 1995; Palmer, 1997; Gordon-Langbein & Metzinger, 1999). Typical classrooms often provide inadequate listening environments with an average noise level of 40-50 dBA (Palmer, 1997; Ray, Sarff & Glassford, 1984). Elevated levels of noise, a student's distance from the teacher and reverberation are all factors that create negative influences on the auditory environment in the classroom (Anderson, 1997). When acoustic conditions are not optimal, there is a negative effect on the transmission of information, as well as the learning process itself. Speech perception, on-task behavior, reading and spelling, behavior, attention, concentration and academic achievement are all adversely affected (Rosenberg et al., 1995; Crandell, 1998; Zabel & Tabor, 1993).

In 1995, ASHA developed a set of standards which addressed the recommended acoustic environment for classrooms. These standards state that ambient noise levels in empty classrooms should not exceed 30 dBA, classroom reverberation time should not exceed 0.4 seconds and the signal-to-noise ratios should be no lower than +15dB. Studies indicated that only 1 in 9 elementary classrooms met the acoustical recommendations for ambient noise levels (Crandell & Smaldino, 1992; Palmer, 1997).

In 2002, the American National Standards Institute standard for acoustical characteristics of classrooms (ANSI S12.60-2002) approved a similar standard proposed by the ANSI S12 Working Group which recommended that unoccupied classroom noise levels not exceed 35 dBA, reverberation time not exceed 0.6 seconds in a room of 10,000 cubic feet or less and 0.7 seconds in a room which is between 10,000 and 20,000 cubic feet, and the signal to noise ratio at a student's ear should be +15 dB (ASHA Special Interest Division 16, 2002). Classrooms today often do not meet these criteria with background noise levels and reverberation times in excess of those recommended (Knecht, Nelson, Whitelaw & Feth, 2002).

Although many educators are aware of the effect that poor classroom acoustics have on those with hearing impairments, they often do not realize the negative impact poor acoustics have on children without hearing loss, particularly young children. The interaction of poor acoustics and limited linguistic knowledge puts every child at risk for learning problems (Rosenberg et al., 1995; Anderson, 1997). Compounding the effect of limited linguistic experience, young learners are at-risk simply because of their age. (Crandell, 1996; Anderson, 1997).

It has also been reported that children who speak

English as a Second Language (ESL), as well as children who live in an environment characterized by poverty and low educational levels of parents, have additional risk factors for learning (Crandell, 1996; Northern & Downs, 1984).

A number of solutions to these acoustical problems exist. They include: physical modifications (such as acoustical ceiling tiles and carpeting), reducing the distance between student and teacher, controlling ambient noise, use of individual amplification systems for at-risk children, and the use of sound field amplification (Crandell, 1998; Berg, Blair & Benson, 1996; Educational Audiology Association, 1998). Sound field amplification is the most cost-effective solution for facilitating learning in typical classroom environments (Berg, Blair & Benson, 1996).

Method

Context

This project took place at a large urban elementary school in New Jersey. Because the average family income in this area fell below poverty level, the district had been identified by New Jersey as one of 26 special-needs districts entitled to "constitutional parity funding." In other words, extra state monies were granted to poorer districts within the state to help bring their spending in line with that of the average per pupil spending of the state's wealthier districts.

Subjects

A total of 39 Kindergarten children who had been registered in two different Kindergarten classes from the School's Early Learning Center participated in this study for a four-month period. The children were all local residents. Economically, each of the children qualified for the free lunch program under federal guidelines.

The researchers could not match the abilities of the children in each of the two classes because the study began mid-year and the composition of each class had already been determined. The school district had agreed to provide sound field amplification in one classroom.

One kindergarten class was designated as the experimental group and housed in a classroom with sound field amplification. That class consisted of 19 students, 9 of whom were bilingual or were characterized as having Limited English Proficiency (LEP). The class with the fewest number of students who were English Language Dominant (ELD) was selected as the experimental group because of the added impact of second language learning. This created a bias against the researchers' hypothesis, which was that sound field amplification would result in a positive effect on children's learning and language skills in a low socio-economic urban environment.

The control group was comprised of 20 students. All of the children in the control group were English Language Dominant. One child in the control group was absent on the day of testing and therefore only 19 of the 20 children were tested.

All of the children included in this study passed an audiometric screening test, which was administered by an ASHA-certified audiologist, using the criteria set forth in the ASHA recommended guidelines for audiologic screening (1996). All of the screenings were performed during the two weeks preceding the study.

Procedures

Prior to ordering sound field equipment, room dimensions were taken and sound level measurements were recorded. When each of the classrooms was empty, sound level meter readings indicated ambient noise levels to be >50 dBA. When children were present in the classrooms, noise levels of 74dBA and 68 dBA were recorded for the experimental class and the control class, respectively.

Observations of students' pre-academic skills, attention, communication, class participation, and social behavior skills were made by the classroom teachers of both groups using the Preschool S.I.F.T.E.R. (Screening Instrument For Targeting Educational Risk, Anderson & Matkin, 1996). The Pre-School S.I.F.T.E.R. is a criterion-based rating scale designed to identify children (age three through Kindergarten age) at academic risk who have been diagnosed or who are suspected of having peripheral hearing loss. The screening instrument is a 15-item rating scale that addresses a child's performance in five specific areas: pre-academics, attention, communication, class participation and social behavior. Ratings range from lowest (1) to highest (5) on three questions within each area. Item ratings are summed to obtain two scores: one for expressive communication and one for socially appropriate behavior. According to Anderson and Matkin (1996), "Analysis has revealed that two factors, expressive communication and socially appropriate behavior discriminate children who are normal from those who are at risk." (Pre-School S.I.F.T.E.R. test form)

It is important to note that although the Preschool S.I.F.T.E.R. is used to identify children who are at risk for developmental or educational problems due to hearing loss, it was chosen because the questions lend themselves to the concerns of early childhood educators. There is precedence for use of a version of this screening tool. Other researchers (Gravel & Wallace, 1995; Flexer, Richards & Buie,

1993) have utilized the original version of the S.I.F.T.E.R. (Anderson, 1989) with populations of children who were neither diagnosed with nor suspected of having hearing loss. The S.I.F.T.E.R. looks at older children (kindergarten through grade 5), and was designed to screen children with hearing loss or suspected hearing loss for academic risk.

The installation of Audio Enhancement's "Deluxe Pal" sound-field classroom amplification system was completed in the classroom that housed the experimental group. The experimental group was exposed to this system for a three-month period. At the end of that time, teachers were asked to again observe students in their classrooms. The Preschool S.I.F.T.E.R. was administered a second time. Additionally, the Test Of Phonological Awareness (TOPA) - Kindergarten Version (Torgesen & Bryant, 1994) was given to all of the children because phonological awareness testing has been shown to be a more potent predictor of first grade reading success than either standardized readiness or intelligence testing (Bradley & Bryant, 1983; Stanovich, 1986; Blachman, 1991; Juel, 1991). This instrument, which can be administered to groups or individuals, serves as a standardized "measure of young children's ability to isolate individual phonemes in spoken words." (Torgesen & Bryant, 1994, p.1) The TOPA-Kindergarten has 20 items, ten of which consist of sounds that are the same, and 10 items with sounds that are different. The TOPA-Kindergarten examines awareness of beginning sounds in words and was normed on 847 children residing in 10 states. It was selected for use in the present study because it was a nationally derived normative sample (Torgesen & Bryant, 1994).

Results

A summary of the study variables is presented in Table 1. Preschool S.I.F.T.E.R. subsection scores are based on ratings assigned to screening instrument items ("1" is the lowest rating, and "5" is the highest rating). Each subsection consists of three items creating a score range of "3" to "15." A range of "15" to "75" points defines the Overall score. TOPA-Kindergarten results are reported as Normal Curve Equivalents (NCE's). Designated items on the Preschool S.I.F.T.E.R. are used to create scores for "Expressive Communication" (EXP) and "Socially Appropriate Behavior" (SAB) and for assigning an at-risk designation for each child in these categories. The proportion of those children in each group at pre-testing and post-testing who are "at-risk" is shown.

Table 1. Summary of Pre-School S.I.F.T.E.R. and TOPA-Kindergarten Scores for Experimental and Control Groups

Preschool S.I.F.T.E.R.	Mean	S.D.	Range	Mean	S.D.	Range
(PA) Pre	8.32	3.13	3-15	7.52	3.45	3-14
Post	12.05	2.63	7-15	8.16	3.96	3-15
(ATT) Pre	9.21	3.60	3-15	5.36	2.99	3-12
Post	11.74	2.92	7-15	7.11	3.81	3-15
(COM) Pre	7.21	2.97	3-13	6.73	3.54	3-14
Post	11.47	3.19	5-15	7.68	3.70	3-15
(CLP) Pre	9.57	2.39	7-15	7.05	3.39	3-15
Post	13.11	2.02	8-15	8.16	3.66	3-14
(SOC) Pre	11.00	2.30	5-15	7.89	2.42	4-13
Post	14.10	1.73	8-15	8.79	3.24	3-15
(OVR) Pre	45.31	10.82	27-71	34.63	14.49	19-68
Post	62.47	9.51	40-75	39.89	16.01	21-74
(TOPA-K) NCE Post	64.47	20.86 (N=17)	30-95	45.90	29.70 (N=20)	3-95
Proportion At Risk For:				Preschool S.I.F.T.E.R.		
(EXP) Pre		.42		.47		
Post		.05		.47		
(SAB) Pre		.32		.84		
Post		.00		.68		
PAC = Pre-academic	SOC= Social Behavior		ATT = Attention		COM = Communication	
EXP = Expressive Communication	CLP = Classroom Participation		SAB = Socially Appropriate Behavior		OVR = Overall	

Pre- and post-test Preschool S.I.F.T.E.R. ratings were collected for experimental and control group subjects. TOPA-Kindergarten scores were generated at the end of the study.

To examine the influence of sound field amplification, effect sizes (ES) were calculated for the subsection and overall Preschool S.I.F.T.E.R. ratings and the TOPA-Kindergarten NCE values. For the purposes of this analysis the post-test S.I.F.T.E.R. ratings were used as outcome measures. ES is defined as the difference between the means for experimental and control groups divided by the standard deviation for the control group using the outcome measure scores (Kavale & Forness, 1985). In essence, ES is a z-score and can be converted to a percentile rank and an NCE. Table 2 lists the ES's and corresponding percentile ranks and NCE's for study variables.

Table 2. Effect Sizes and Corresponding Percentile Ranks and Normal Curve Equivalents for Study Variables

Variable	ES	Percentile	NCE
Preschool S.I.F.T.E.R.			
PAC	0.98	.84	70.9
ATT	1.22	.89	75.8
COM	1.02	.85	71.8
CLP	1.35	.91	78.2
SAB	1.64	.95	84.6
Overall	1.41	.92	79.6
TOPA-K	0.63	.74	63.5

It can be seen in Table 2 that ES's ranging from 0.63 to 1.64 emerged. According to Kavale and Forness (1985) "an ES of +1.00 indicates that a subject at the 50th percentile of the control group would be expected to rise to the 84th percentile of the control group at the end of treatment. The average subject receiving treatment would be better off than 84% of the control group while only 16% of the control group would be improved after treatment" (p.15). The ES's for the Preschool S.I.F.T.E.R. ratings in this study indicate that the range of treatment subject's ratings would be "better off" than 84% to 95% of the control group subjects on respective subsections and "better off" than 74% of control group subjects on the TOPA-Kindergarten.

An essential feature of the Preschool S.I.F.T.E.R. is to identify children who are "at-risk" for expressive communication and socially appropriate behavior difficulties. Table 3 shows the proportion of children in the "at-risk" category for each group for each Preschool S.I.F.T.E.R. category. It can be seen in Table 3 that the number of children assigned the "at-risk" designation decreased from 8 to 1 (Expressive Communication) and from 6 to 0 (Socially Appropriate Behavior) for the experimental group. For the control group for Expressive Communication the number of "at-risk" children remained the same, while the number of "at-risk" children decreased form 16 to 13 for Socially Appropriate Behavior. The data in Table 3 were subjected to determining the "differences between proportions" (Matson, 1981).

Table 3. Significant Differences Between Proportions for At-Risk Assignment for Experimental and Control Groups for Expressive Communication and Socially Appropriate Behavior of the Preschool S.I.F.T.E.R.

Preschool S.I.F.T.E.R. Variable		Experimental Group	Control Group	Z	P
Expressive Communication	Pre	.42 (8/19)	.47 (9/19)	.311	NS
	Post	.05 (1/19)	.47 (9/19)	2.98	.001
	z	2.76	0.00		
	p	.001	NS		
Socially Appropriate Behavior	Pre	.32 (6/19)	.84 (16/19)	3.25	.001
	Post	.00 (0/19)	.68 (13/19)	2.58	.001
	z	2.38	1.14		
	p	.001	NS		

The differences in proportions show that the number of children who were assigned to the "at-risk" categories decreased significantly for the experimental group while there was no significant change in the proportions of "at-risk" assignment for the control group. The proportion of the control group children assigned to the "at-risk" category was significantly higher than experimental group children at both pre- and post-testing except for expressive communication at pre-testing.

Discussion

The number of children who were assigned to the "at-risk" categories on the Preschool S.I.F.T.E.R. decreased significantly for the group of children who were exposed to sound field amplification (the experimental group). These results occurred despite the fact that the experimental group contained all of the children that participated in the study who were either bilingual or characterized as having Limited English Proficiency.

Classroom learning is highly dependent on a child's ability to listen to both the teacher and the other students in the classroom. It would seem logical, therefore, that a child must be able to hear clearly and understand what is being said if that child is to learn. Young children with normal hearing may not hear an entire message when listening to speech in a noisy room. Unlike adults, who can "fill in the blanks" if they miss parts of a spoken message, children with limited language experience are often unable to do this. Studies have shown that poor classroom acoustics can compromise academic performance, as well as affect concentration and attention. The data for appropriate classroom acoustics exist, but research has indicated that these data are widely ignored.

The school selected for this study is an inner-city school, which serves a low socio-economic area with a large population of children who are bilingual or have Limited English Proficiency. It has many more children at risk for academic problems than other communities in the state. It may be thought of as a microcosm of many inner city schools in this country. While a school system cannot address all of the cultural and economic factors that may contribute to learning problems, it may be able to offset a number of problems through the use of sound-field amplification, a relatively low cost option. The implications of this study are important because the data illustrate that risk for a number of language/learning problems was virtually eliminated in the experimental group with minimal expense and little, if any extra effort on the part of school personnel.

This study should be replicated with a larger number of students. It would also be of interest to follow the academic progress of this initial cohort to determine whether or not the effect of a rich acoustic environment is seen on other standardized measures of reading and language during their early childhood education.

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