

Effects of Soundfield Amplification on Spelling Performance of Elementary School Children

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The purpose of this study was to determine if soundfield amplification in the classroom improved spelling performance of upper elementary regular education students. A total of 145 third, fourth, and fifth grade students were administered two tape recorded Curriculum Based Measurement spelling tests that were balanced for difficulty, number of letters in the words, and the number of phonemes "s, f, and th". In one condition the test was presented at a signal-to-noise (S/N) ratio of 0 dB, while in another condition the test was presented at about a +12 dB S/N ratio with a soundfield amplification system. Statistically significant improvement in spelling scores was achieved in the better S/N ratio for all grade levels.

Use of classroom soundfield amplification has been explored for the purpose of providing a clearer auditory signal for elementary school students with unaidable, mild, unilateral, or temporary hearing losses. Introduced to schools in southern Illinois in the 1970's (MARRS Project), the school systems reported improvement in academic performance for third, fourth, and fifth grade students who had academic delays and mild hearing losses when they were assigned to amplified classrooms (Sariiff, 1981). These students made greater academic progress when compared to both students in non-amplified classrooms who received no special treatment and to students who received resource room assistance for their academic weaknesses. Another study (Flexer, Millin & Brown, 1990) found that primary school students with developmental delays and mild hearing losses performed better on word identification tasks in an amplified classroom when compared to unamplified classrooms.

In a study of kindergarten students, Jones, Berg & Viehweg (1989) showed that students with mild hearing losses improved their word discrimination in amplified over unamplified soundfield conditions. In addition, this study reported that when the verbal stimulus was at a distance of twelve feet from the students, kindergartners with normal hearing also improved in word-discrimination abilities in the amplified condition.

The finding that students with normal hearing also improved their auditory discrimination in an amplified soundfield prompted the question: Does soundfield amplification improve academic performance of regular education elementary students? The present study was conducted to determine if regular education students in third, fourth, and fifth grade would demonstrate improved

spelling performance in amplified versus unamplified conditions using a soundfield amplification system. It was hypothesized that spelling test scores would improve as conditions for auditory discrimination improved.

The academic area of spelling was selected because it was thought to be sensitive to auditory discrimination and the most likely area to demonstrate the immediate effect of amplification. Tests could be administered with a tape recorder to control for volume and to maintain a constant stimulus across groups. Tests could also be controlled for difficulty and the number of high frequency phonemes ("s, f, and th") so that two comparable spelling lists could be generated.

Student spelling performance was assessed utilizing Curriculum Based Measurement (CBM) standardized presentation and scoring procedures. CBM was designed to measure growth and individual differences in academic performance using students' normal areas of study. Spelling tests can be administered in a group setting. CBM scoring procedures award points for consecutive letters correct, not just for a correct whole word making it a more sensitive tool for measuring spelling (Shinn, 1989).

METHOD

Subjects

Subjects were 145 students in third, fourth, and fifth grades in a small midwestern elementary school. (See Table 1 for characteristics of the subject population.) Subjects were tested, in their normal class groupings with two classes per grade level. Students had been randomly assigned to the classes with equivalent numbers and sex distribution in each class at the beginning of the school year. Differences in class size at the time of testing were due to normal attrition.

Table 1. Student Demographic Information.

Grade	Number	Female/Male	Calendar Age		ITBS*
			Mean	Range	
3	47	23/24	9:4.7	8:8-10:5	57%
4	53	27/26	10:5.0	9:8-11:6	58%
5	45	22/23	11:4.3	10:8-12:5	46%

*Iowa Test of Basic Skills; Iowa percentile

The student population had a typical distribution of mild, fluctuating hearing loss with no student having a permanent loss. This was documented by annual hearing screening at 20 dB at 500 Hz and 15 dB at 1K, 2K, and 4K Hz. Screening took place two months prior to the experiment. Hearing rechecks which included tympanometry occurred two weeks later for those students failing the screening. In the third, fourth, and fifth grades, 11%, 10%, and 7% failed the initial screening, respectively. At the time of hearing rechecks, only one student at each grade level continued to show a mild, conductive hearing loss. This pattern of fluctuating hearing loss is common in elementary school students due to the incidence of otitis media, with percent of incidence decreasing with age (Harford, Bess, Bluestone, and Klein, 1978).

Apparatus and Stimuli

The room used for the experiment was a classroom within the elementary school building which was chosen for its availability on the day of the experiment. The configuration of this classroom was typical of the general education classrooms within the building (see Figure 1).

The soundfield amplification system used was a Lifeline Classroom Amplification System consisting of a Samson VLP wireless microphone transmitter and receiver, a Realistic MPA-25 amplifier, and four Tandy 2.5 speakers, placed as noted in Figure 1, at a height of one meter. Sound level readings were taken on the test day prior to testing and between each experimental group at five sites (Appendix A) with a Quest (Model 155) sound level meter using a white noise tape recorded signal set at 66 dB. This signal level gave an average S/N ratio of +12 dB with the Lifeline System turned on as measured at the five sound level test sites. White noise was used to produce a constant signal and to aid in the accuracy of the measurement. All seats within the classroom received the sound signal at equal volume (+2 dB) when the four speakers were placed as noted in Figure 1. Speakers remained in this position throughout the experiment.

Two spelling lists of twenty words each were generated for each grade from grade-level spelling words specified in the Iowa Spelling Scale (1954). They were selected from the final seven spelling lists used within the schools for the school year so that none of the words had been taught in spelling lessons at the time of this experiment. Lists for each grade were balanced first for length of word and degree of difficulty (Green, 1954), and then for number of phonemes 's, f, and th'. With the limited set of spelling words to choose from the first two criteria were the most critical for creating matched CBM spelling test lists. As it is presumed that correct spelling depends partly on hearing all the phonemes of the word, an attempt was also made to balance for the same number of three low power, high frequency phonemes ('s, f, and th') to make the listening task as equally difficult as possible between lists. With the limited set of words to select from, other phoneme characteristics such as position within the word could not be matched in both lists. Homonyms were not used. (See Appendix B for word lists.)

Student spelling test directions, based on the CBM administration manual directions were recorded, followed by the twenty word lists. (See Appendix C for test directions.) Each of the twenty words was spoken twice with the initial presentations of the words seven seconds apart (Shinn, 1989). A Sony tape recorder (TC-153SD) using a Shure microphone (585SA) was used for the recording in a Tracoustics acoustical enclosure (RE-142). Peak dB levels were held constant for each word. The same female voice was used on all recordings and the same tape recorder was used to administer all spelling tests.

Procedure

Six classes of students (two at each of three grade levels) were tested in their normal class groupings. Students were allowed to choose their own seats in the test room. Response sheets and pencils were placed at each seat. Students were instructed to write their desk numbers on the back of each paper in the place provided. Because the CBM procedures were new to them, directions were first given live-voice, followed by a five word practice list presented via the tape recorder in the same experimental condition which was to be administered first. The tape recorded test was then played for the class. Following the completion of the

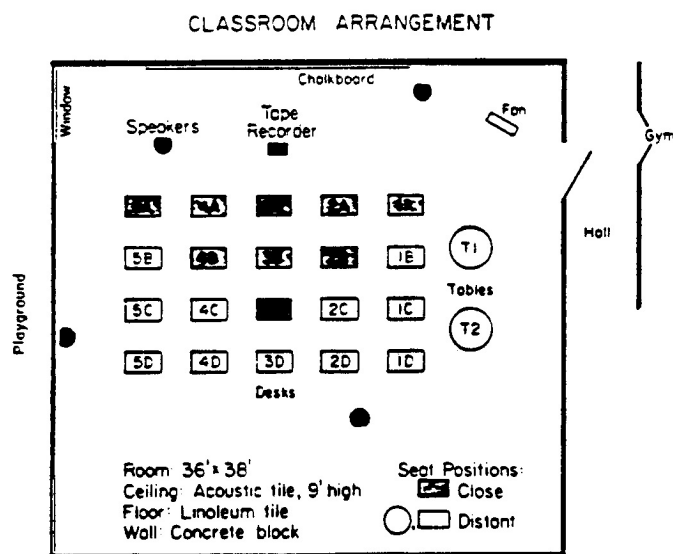


Figure 1. Classroom arrangement for testing showing the position of the tape recorder and amplification speakers in relation to the student's seating positions. Note that those desks within 10' of the tape recorder ('Close') are shaded. Factors affecting the acoustical characteristics of the room are also described.

first test, students were told to pass in their response sheets. They were allowed to relax while response sheets were collected and new ones distributed, which took approximately five minutes. Then the second spelling test was given utilizing the same procedure. The order of presentation of the amplified condition was counter-balanced with each grade. In this way, both spelling list A and list B were amplified one time at each grade level.

Unamplified lists were played from the tape recorder placed on the teacher's stool (center front) and set at 53 dBA measured at a distance of one meter (Desk 3A). This dB level was selected because readings taken of teachers' voices within this elementary school showed this to be the quietest average voice level of a teacher when addressing her class. (The range of lecturing voices was 53-72 dBA.) For the amplified condition, the spelling lists were broadcast through the soundfield system at a volume of 66 dBA for a signal gain of +13 dB in a unoccupied room.

Background noise levels within the classroom were measured with each experimental group while testing was in progress. They averaged 50 to 53 dBA with momentary peaks (maximum 62 dBA). Primary contributors to this ambient noise level were playground and gymnasium sounds, and fan noise. No testing was done while classes were in transition in the hallway. Appendix A presents a summary of sound level measurements at selected seat positions.

All spelling tests were scored by two independent scorers who had been trained in CBM procedures (see Appendix D). Interjudge reliability averaged .98. When there was a scoring disagreement, usually due to handwriting clarity, a third scorer was used.

RESULTS

A single factor analysis of variance was used to analyze test results for each grade level. Results indicated a statistically significant difference in spelling scores in each grade level with the amplified soundfield condition (the values being: third grade, $F=88.722$, $df=1/46$, $p<.001$; fourth grade, $F=61.047$, $df=1/52$, $p<.001$; fifth grade, $F=124.376$, $df=1/44$, $p<.001$). Figure 2A compares means of the amplified and unamplified conditions at each grade level. Results were also analyzed by proximity to speaker (Figure 2B). Within ten feet of the speech source (i.e., tape recorder), the students would be listening mainly to direct speech. At a further distance, students hear both direct and reverberant speech which would interfere with discrimination (Berg, 1987). Spelling scores improved with soundfield amplification in both close and distant positions. This difference is significant in the distant seat positions.

DISCUSSION

Previous studies have indicated that classroom amplification can enhance academic performance of students with a hearing loss. Personal amplification units have long been used for this purpose.

More recent studies have indicated that auditory discrimination of students with no hearing losses as well as those with mild hearing losses improved with soundfield amplification in a classroom setting.

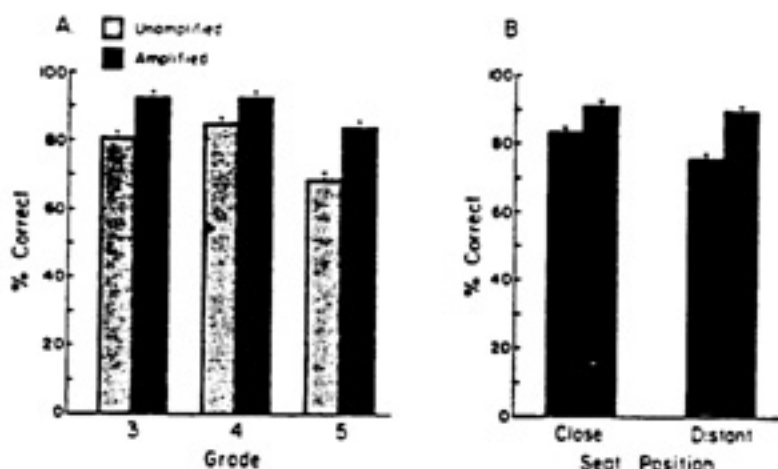


Figure 2. Mean spelling test scores comparing unamplified and amplified listening conditions for (A) each grade and for (B) seat position proximity to the tape recorder. See Figure 1 for the arrangement of the desks.

The present study indicates that general education students' spelling performance is improved in soundfield amplified conditions. With students present, the classroom in this study had background noise levels of 50-53 dBA which is within normal limits (Berg, 1987). The teacher with a quiet voice (53 dBA) would have presented the spelling test at a 0 dB S/N ratio (unamplified condition). In this poor listening condition and with unfamiliar spelling words being presented, the unamplified spelling test scores of 70-80% were remarkable. Even more remarkable, soundfield amplification (+12 dB S/N ratio) made a statistically significant difference in their academic performance. Benefit was realized by students in both close and distant proximity to the signal, with more improvement seen by students distant from the sound source. Those students distant from the speaker had lower scores on the unamplified lists than those nearer the speaker. Under amplified conditions scores were nearly the same between the close and the distant groups. This suggests that the soundfield amplification system affords all students in the room equal opportunity for learning.

Further study should focus on which specific student populations in the regular education classroom (e.g., students with Attention Deficit Disorder or students receiving Speech/Language services) may benefit the most academically from the use of a soundfield amplification system in their classroom. This would help in making more specific recommendations to principals, teachers, and parents. Classroom observations of students with ADD have shown an improvement in on-task behavior with soundfield amplification. In a pilot CBM study, the only subgroup of students to show significant improvement in spelling test scores with +20 dB S/N ratio compared to +10 dB S/N ratio in the unamplified condition were the students receiving SLP services. About 90% of these students had a history of chronic otitis media as preschoolers.

Further study could also address teacher voice level and S/N ratio to determine at what S/N ratio there is no longer a significant improvement in speech discrimination.

ACKNOWLEDGEMENTS

We gratefully acknowledge the support and contributions of Doug Schermer and Susan Thomsen and Bob Gillum.

Lifeline Classroom Amplification Systems, Platteville, Wisconsin, generously provided soundfield amplification system for use in this research.

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APPENDIX A

SOUND LEVEL MEASUREMENTS (dBA)
WITHIN THE CLASSROOM

Listening Condition	Selected Seat Position					Signal/Noise Ratio
	3A	1B	5B	3C	1D	
UNAMPLIFIED						
(Tape Recorder only)						
— without students in room	53	50	50	48	47	0
— with students*	50	—	—	—	—	
AMPLIFIED						
(Amplification System + Tape Recorder)						
— without students	67	66	66	67	68	+13
— with students	64	62	62	64	64	+10

*Unable to measure accurately at some seat positions due to a background noise level of 50-53 dBA with students present.

APPENDIX B

Third Grade Spelling Lists		Fourth Grade Spelling Lists		Fifth Grade Spelling Lists	
List A	List B	List A	List B	List A	List B
water	cookies	thousand	needless	organize	exercise
ears	bags	thunder	gardens	poems	ditch
spoon	wings	chapter	picture	existing	includes
file	cuts	differ	flight	campus	couple
picked	killed	blanks	floors	victim	author
snap	gray	apron	helps	happily	lettuce
filling	kittens	except	excuse	venture	orchard
brass	trust	worship	respond	resort	blouse
cane	cage	frankly	kindest	welfare	credits
moved	drove	quart	noble	groups	chosen
crown	desks	dining	suffer	occupied	notified
near	left	sound	bunch	freight	hurried
club	leap	oldest	member	cheek	crawl
lad	tag	blaze	death	selfish	mixture
takes	asked	begging	harvest	avoid	fault
short	fight	couch	joint	measure	further
posters	strings	wage	rage	steady	beauty
baking	grand	express	contain	stroke	decide
jumps	keeper	folks	scrap	distance	answered
flat	must	hither	honest	proof	ankle

APPENDIX C

Directions for Administration of Spelling Tests

1. You should have a sheet of paper in front of you. Write your desk number at the top where it says "desk".
2. I want you to write the words on the sheet in front of you. Write the first word on the first line, the second word on the second line, and so on. I'll give you 7 seconds to spell each word. When I say the next word, try to write it, even if you haven't finished the last one. Are there any questions?"
(Tape recorded spelling lists.)
3. "Stop. Put your pencils down."

(Shinn, 1989)

APPENDIX D

CBM Spelling Scoring Procedures

1. Mark a caret (^) for each Correct Letter Sequence (CLS). (A letter sequence is a letter pair that is sequenced correctly.)
Beginning and ending letters are correct if they are adjacent to a correct empty space.
Example: is
2. Give one point for each correct letter sequence.
Example: table = 6
3. Letter reversals ARE errors.
4. An omitted letter will not count in two sequences.
Example: because = 8
 because = 6