Classroom Acoustic Accessibility: Understanding Children as the Dominant Noise Source

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Hearing is Essential

- Hearing is a first-order event for the development of spoken communication and literacy skills.
- Anytime the word *"hearing"* is used, think *"auditory brain development"!!*
- *"Acoustic accessibility"* of *intelligible* speech is essential for brain growth.
- *Signal-to-Noise Ratio (SNR)* is the key to hearing intelligible speech.

Neurological Issues

- We hear with the brain -- the ears are just a way in! What's the big deal?
- Human adults are rich in auditory brain tissue – *But children cannot hear like adults!* **Why?**
  1. Higher auditory brain centers are not fully mature until a child is about 15 years old.
  2. Children without years of language and life experience cannot fill in the gaps -- called auditory cognitive closure -- like adults do.
- Therefore, **all** children need a quieter environment and a louder signal than adults.

Pay Attention! (Doidge, 2007) The Brain that Changes Itself

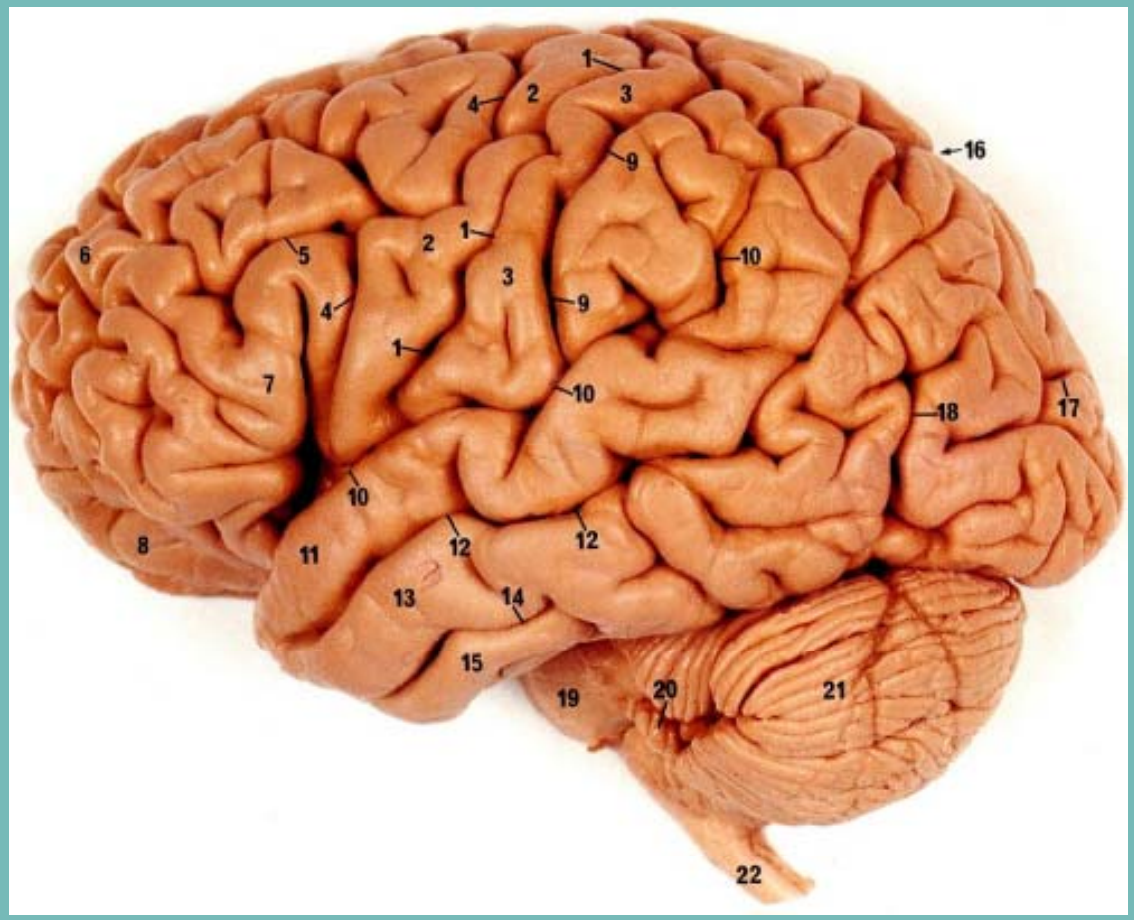
- “When we want to remember something we have heard, we must hear it clearly because memory can be only as clear as its original signal....muddy in, muddy out.” p. 68
- Learning new information/tasks/skills requires active attention.
- “While we can learn with divided attention, divided attention does not lead to abiding changes in your brain maps”. p. 68

IT'S ALL ABOUT THE BRAIN

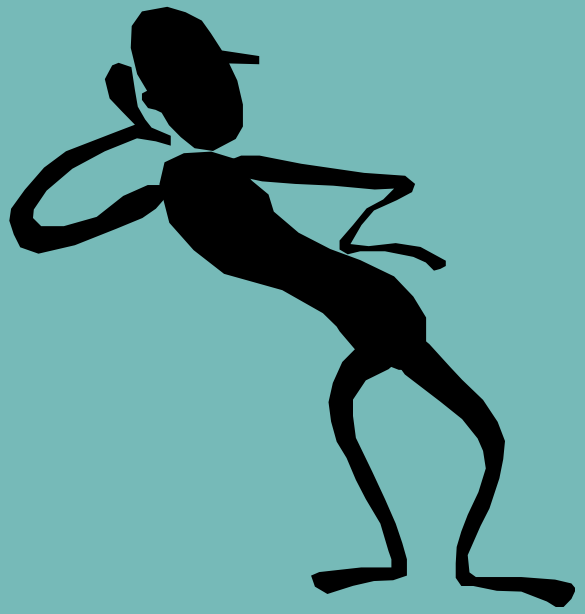
Poor acoustic access is not about the ears; it's about the brain!

Sound field systems are not about the ears; they are about the brain!

The Ear

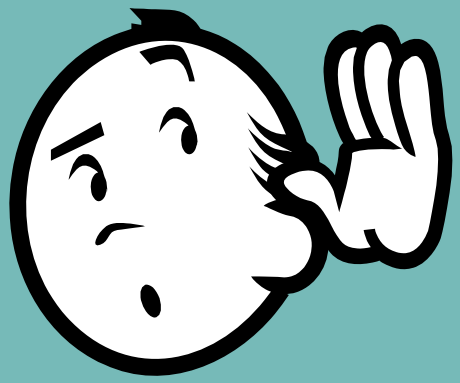


WHAT ARE THE BASIC CLASSROOM LISTENING ISSUES?



The hearing of the child, the acoustic environment, and the speech of the teacher, ALL are Variables - not constants !

As variables, they can and indeed must be managed



Mainstream classrooms are auditory-verbal environments

“Listening”

is the cornerstone of the educational system.

Children spend up to 70% of their school day listening.

Children are the biggest source of noise in the classroom.

If a child cannot clearly hear and attend to spoken instruction, the entire premise of the educational system is undermined.

A sound field system is a *teaching tool* to access this auditory environment.

SIGNAL-TO-NOISE RATIO

ALSO CALLED SPEECH-TO-NOISE RATIO

This is the basis of classroom listening.

- **Signal-to-noise ratio** is the relationship between the primary or desired auditory signal to all other unwanted background sounds.

- The more favorable the signal-to-noise ratio, the more intelligible the spoken message.

- Adults with normal hearing require a signal-to-noise ratio of approximately *+6 dB* in order to hear the spoken message as consistently intelligible.

- The desired signal needs to be about *twice as loud* as background sounds.

The following populations require a much more favorable signal-to-noise ratio in order to receive intelligible speech -- these groups need the signal-to-noise ratio to be approximately +15 dB to +20dB -- the desired signal needs to be about 10 times louder than background sounds!

- Typical children.
- Children with any type and degree of hearing problem including ear infections and unilateral hearing loss.

- Children with auditory processing problems.
- Children with learning disabilities.
- Children with attention problems.
- Children with behavior problems.
- Children with developmental disabilities.
- Children with visual disabilities.
- Children whose first language is not the language of the speaker.

Unfortunately, typical classrooms have an *inconsistent* and poor signal-to-noise ratio of about +4 dB.

- A classroom's signal-to-noise ratio can vary minute by minute from about +5 dB to worse than -20dB, depending on teacher and pupil positions and background noise.

Two Ways to Manage, Improve, and Control the Signal-To-Noise Ratio (S/N)

- Positioning: Remain, physically, as close as possible to the desired sound source -- ideally within 6 inches.
- **Unfortunately**, physical positioning does not work in a classroom environment where teacher and pupils cannot remain in fixed positions.

Acoustic Accessibility Requires that Classroom Barriers to Good Listening Must Be Removed.

Barriers -- Physical

- Distracting sound intrusions (horns, airplanes, noisy corridors, band practice)
- Reverberation (speech-masking echoes muddle consonant sounds that define words)
- Background noise (traffic, air conditioning, students) decreases SNR

Barriers -- Physiological

- **Hearing impairment**
- **Temporary hearing loss (Otitis Media occurs in 25% to 30% of students in early grades)**
- **Lack of language proficiency, including English-as-a-second-language students**
- **Immature auditory cognitive development**

Solutions -- Physical

- **Stop noise intrusion with exterior walls and floor-to-floor interior partitions that reduce sound transmission**
- **Cut Reverberation Time (RT) with sound-absorbing material -- acoustic ceilings, soft wall materials, carpeting**
- **Reduce background noise of air conditioning, computers, instructional equipment, chair scraping**

The Ultimate: Anechoic Chamber

Solutions -- Physiological

- **Reduce student-generated noise with effective class management techniques**
- **Provide spoken-voice sound levels that students can readily hear over the background noise – Signal-to-Noise Ratio (SNR) of +15 to +20 decibels**

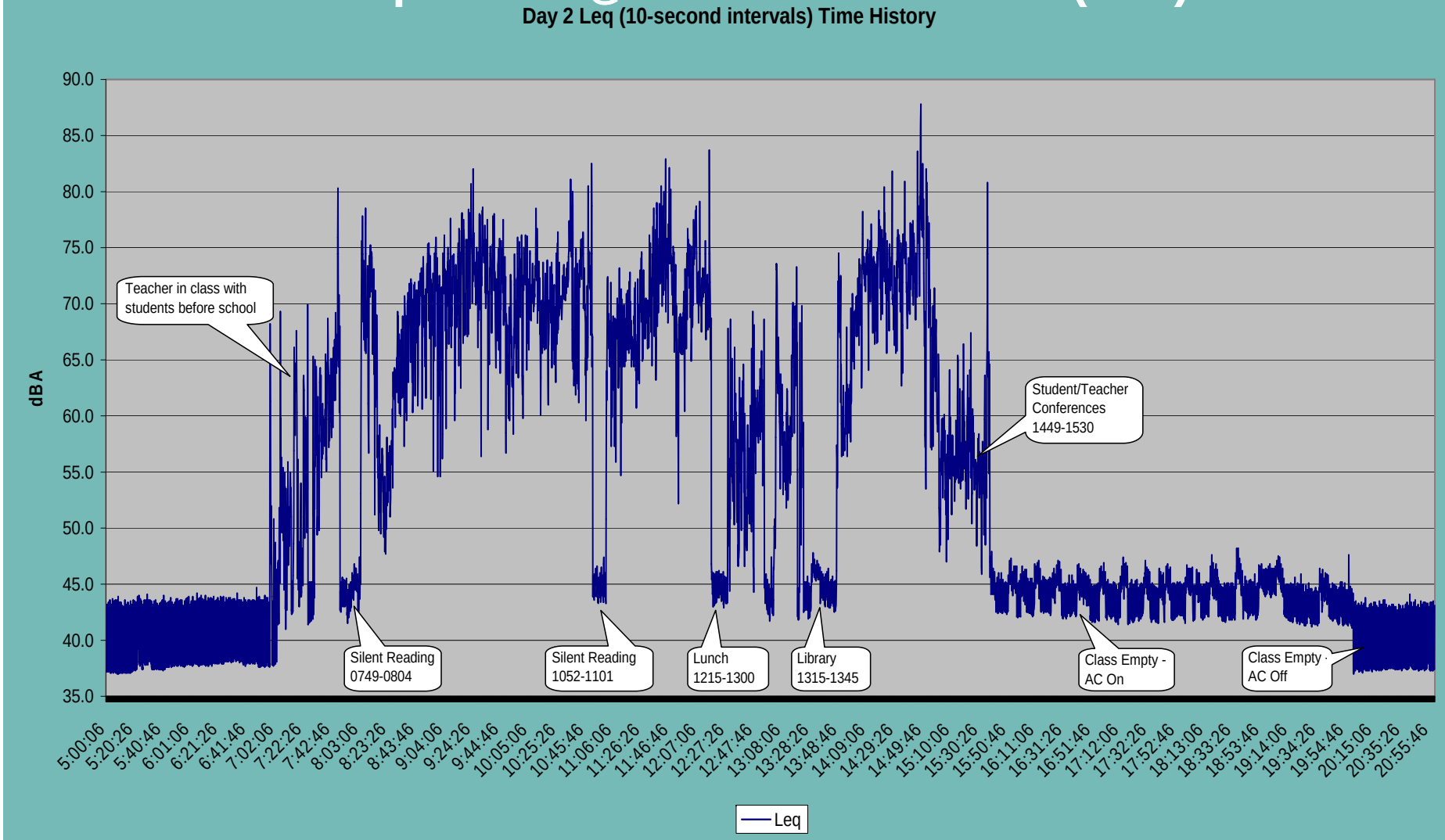
Classroom Acoustical Conditions

What is the Noise Level in a working Classroom??

- **Two days of actual sound levels recorded in a 30-student 4th-grade classroom**
- **Correlated by teacher to classroom activities**
- **Statistically analyzed for Time History (10-sec. Leq intervals) and equivalent sound-pressure levels (Leq) and background levels (L 95) for 60- minute periods**
- **Following chart shows Time History sound-pressure levels correlated to class activities**

Classroom Sound History – One Day

L equivalent @ 10-second Intervals (dBA)



“Average” Sound Levels
General (Leq) and Background (L95)

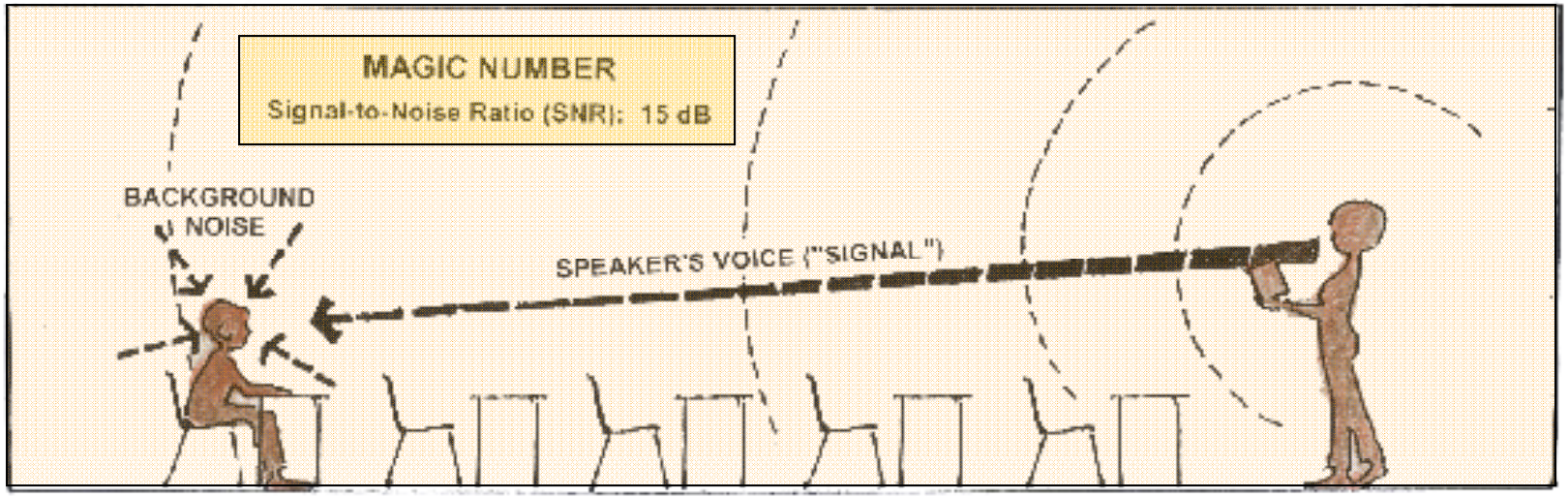
- “Working together/talking” activities are 67 to 72 dBA Leq
- “Silent Reading” levels are about 45 dBA – 1-2 dB higher than the unoccupied levels, and in many classrooms, “silent reading” levels are in excess of 50 dBA
- Background levels (L95) are 43 to 52 dBA
- Unoccupied levels during lunch, before and after school are about 43 to 45 dBA Leq with HVAC on

Background Noise Levels

- **Background noise levels ranging from 43 to 52 dBA exceed ANSI Std. 12.60 level of 35 dBA by 8 to 17 dBA**
- **HVAC noise levels of 45 have little effect – below 43 have no effect -- on background noise.**
- **So, how do students receive a SNR of +15 dBA without teachers screaming at 80 dBA?**

“Signal to Noise Ratio” is the Critical Factor

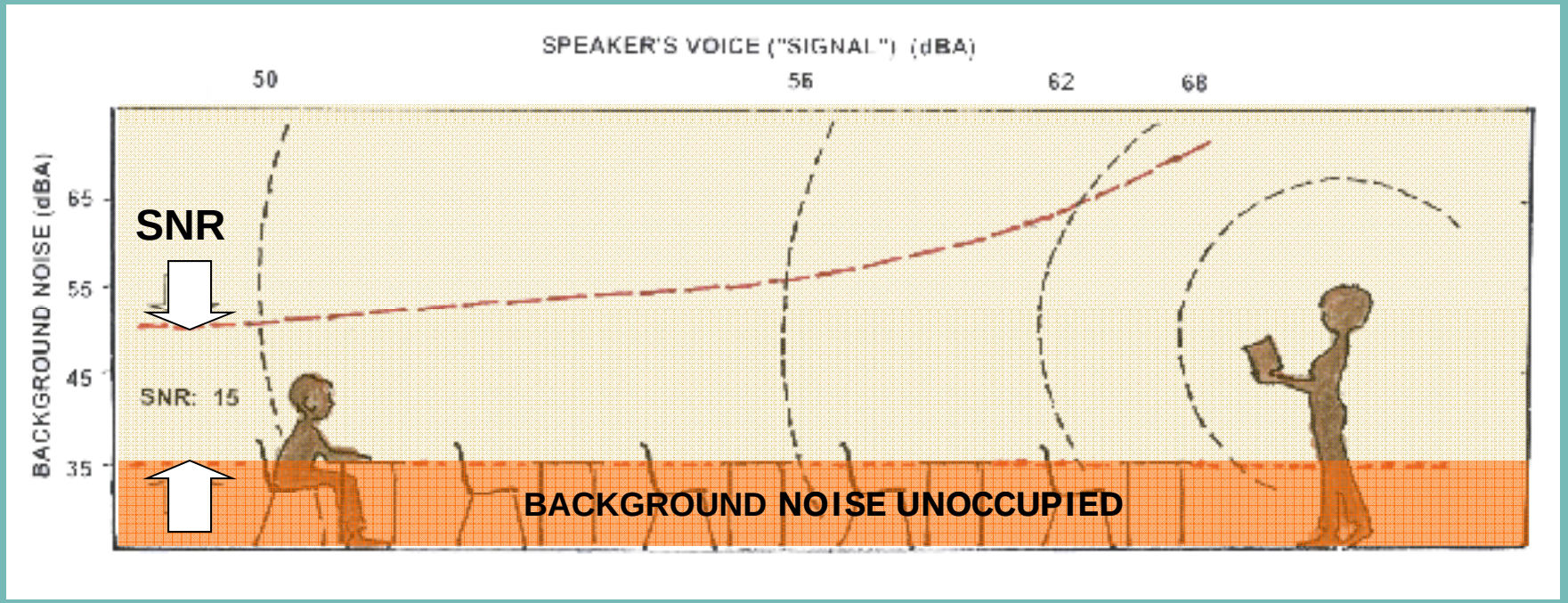
Teacher’s Voice Level Decreases with Distance
Research shows that students need
SNR = +15 dB to receive intelligible speech



Acoustic Environment in an Unoccupied Classroom

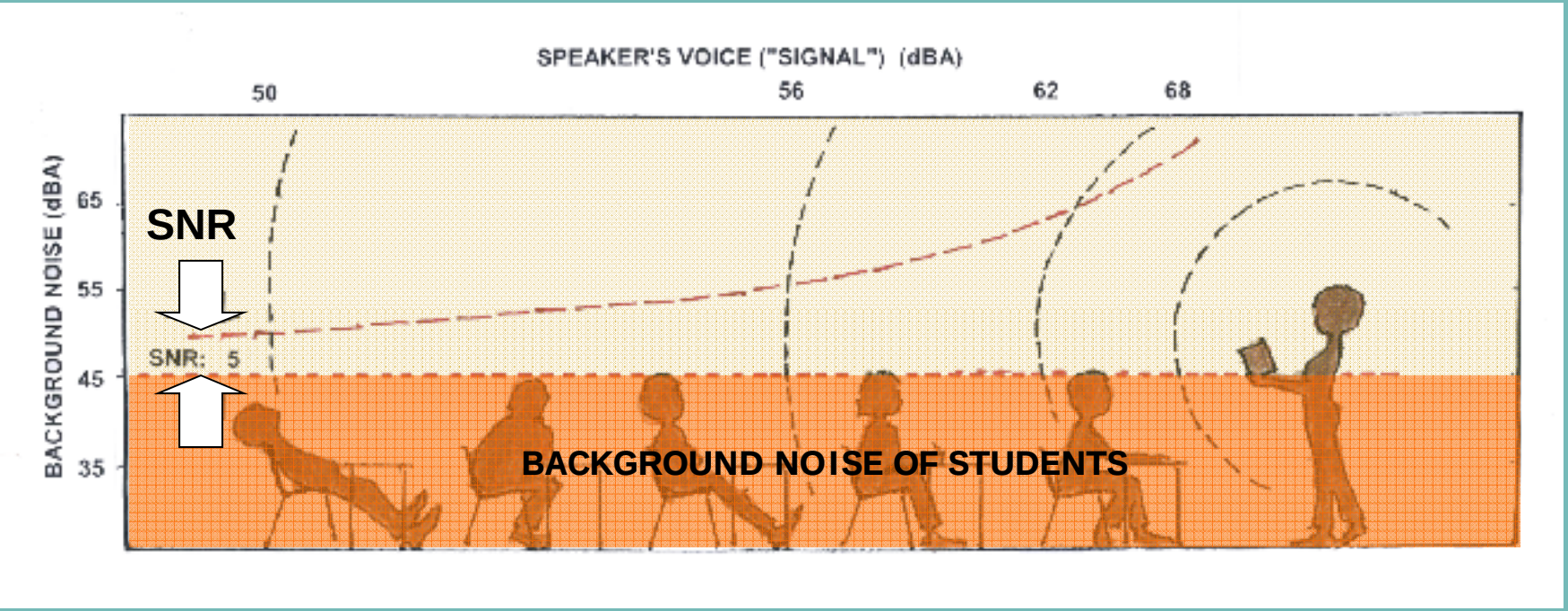
Background Noise @ 35 dBA per ANSI Standard 12.60

SNR = +15 dB



Acoustic Environment in an Occupied Classroom

Background Noise @ 45+ dBA in Measured Sound Levels (L 95)
SNR = +5 dB



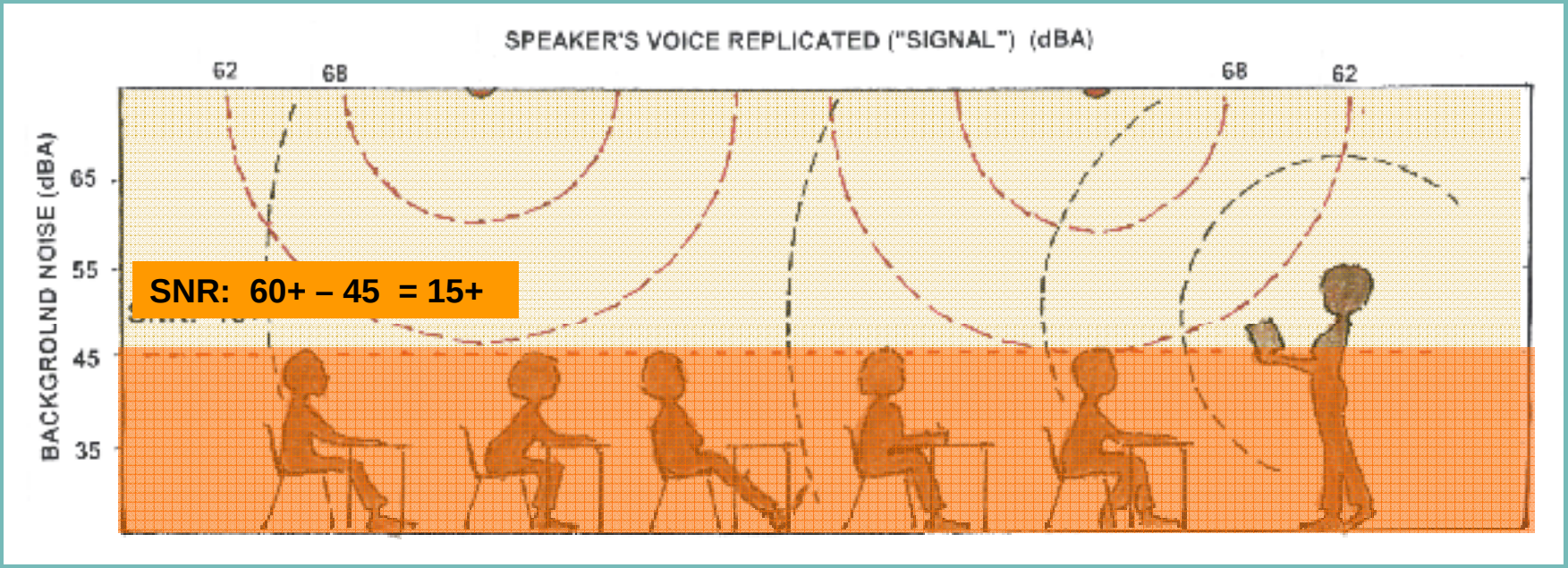
Sound Field Technology

- **Student-generated Noise** is unavoidable – clattering, shuffling, shifting, moving pencils and books, coughing, sighing, whispering.
- **Solution:** Raise the **Signal**. Enhance the sound of the teacher's voice and replicate it throughout the classroom.
- **Then, every student receives an intelligible signal regardless of where they are seated.**

Sound Improvement of Spoken Instruction

Teacher's Voice Replicated – Not Amplified - at 4 Ceiling Speakers

SNR = +15 dB



Has sound field technology been successful?

- **Classroom installations are growing exponentially, especially as part of “smart classrooms”.**
- **System providers have grown from 5 to 15 or more in past few years.**
- **Acceptance and endorsement by users has been universally positive.**

What do students say?

- “Now I can hear.”
- “It sounds like the teacher is right behind me.”
- “ I don’t have to keep raising my hand to ask, ‘What did you say?’”
- “”My teacher has finally stopped yelling!”

What do teachers say?

- “They are more likely to ask questions and more likely to participate.”
- “I don’t have to keep repeating myself.”
- “You know, I think they are better behaved.”
- “It makes an amazing difference. I’ve never had to raise my voice to the kids.”
- “The downside is I can’t get it in the classrooms fast enough.” (Superintendent)

Teachers also save their voices.

- On average, teachers talk for 6.3 hrs./day
- In a study, 20% of teachers reported voice problems caused 1 day to 1 week absence.
- Another study found 21% of teachers had pathological voice conditions.
- Because of voice problems, 4% of teachers considered career change.
- Teachers of any age are at high risk for vocal abuse. And high classroom noise levels have been shown to increase stress and fatigue.

With Sound Field Technology, not “blasting amplification” . . .

. . . but a quiet classroom through sound replication!

In acoustically well-designed CR's, Sound Field Technology brings ...

- **Better acoustic access, fewer misunderstandings, better learning.**
- **More focused attention, better behavior.**
- **Less classroom stress from high voice levels.**
- **Fewer referrals to special education or ADHD assessment.**
- **Reduced student and teacher absenteeism.**

In-service Instruction for Effective Sound Field Use

- Create the context for sound field use
- Teacher's voice – quiet and soothing rather than anxious and loud
- The sound system allows the room to be quieter, not louder through sound replication
- Use the microphone to settle the class – not yell at the students
- Direct pupils' auditory attention
- Maintain auditory focus

FOR SOUND FIELD TECHNOLOGY TO BE EFFECTIVE, IT MUST BE:

- **Installed appropriately!**
- **Used appropriately following teacher inservices!**
- **Maintained appropriately!**

SUMMARY

SOUND FIELD AMPLIFICATION:

- **addresses the neurological, linguistic and experiential limitations of children;**
- **accesses the auditory environment of the classroom at all grade levels;**
- **strikes at the auditory core of literacy;**
- **increases the probability of addressing AYP for all children**

Sometimes the simplest concepts are the most powerful.

BRAIN, BRAIN, BRAIN!!!

The purpose of acoustic accessibility is to access, grow and develop auditory brain centers.

GENERAL REFERENCES

- Cole, E., & Flexer, C. (2007). *Children with Hearing Loss: Developing Listening and Talking, Birth to Six.* San Diego: Plural Publishing.
- Madell, J., & Flexer, C. (2008). *Pediatric Audiology: Diagnosis, Technology, and Management.* New York: Thieme Medical Publishers.
- Doidge, N. (2007). *The BRAIN that changes itself.* London: Penguin Books Ltd.

Textbook/Handbook

SOUND FIELD AMPLIFICATION: APPLICATIONS TO SPEECH PERCEPTION AND CLASSROOM ACOUSTICS, 2ND EDITION (2005)

by Carl Crandell, Joseph Smaldino and Carol Flexer

Published by Thomson Delmar Learning

DVD: "Literacy, Classroom Amplification and the Brain"

by Carol Flexer

Order from INFO-LINK Video Bulletin at www.ladnarmedia.com

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