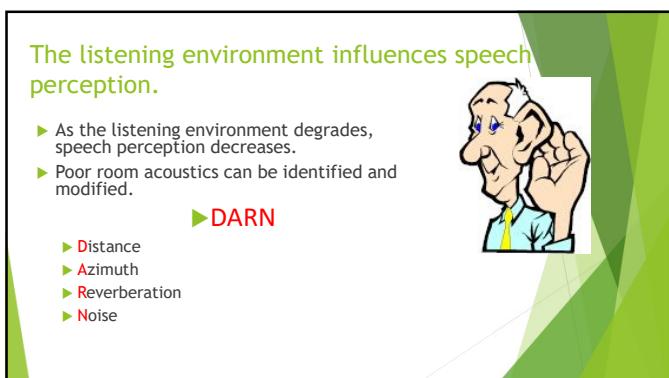




4: Improving the Acoustic Environment

Improve Signal that Gets to the Listener

1



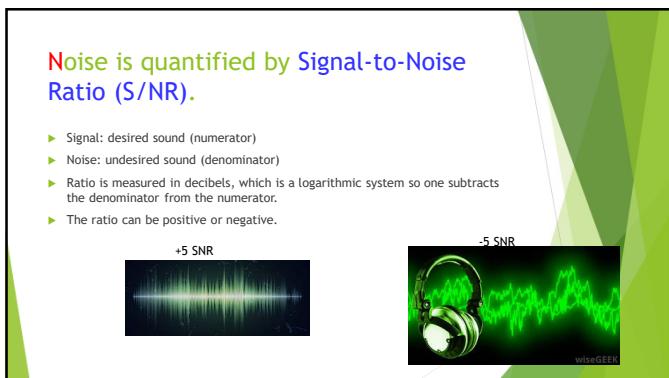
The listening environment influences speech perception.

- ▶ As the listening environment degrades, speech perception decreases.
- ▶ Poor room acoustics can be identified and modified.

► DARN

- ▶ Distance
- ▶ Azimuth
- ▶ Reverberation
- ▶ Noise

2



Noise is quantified by **Signal-to-Noise Ratio (S/NR)**.

- ▶ Signal: desired sound (numerator)
- ▶ Noise: undesired sound (denominator)
- ▶ Ratio is measured in decibels, which is a logarithmic system so one subtracts the denominator from the numerator.
- ▶ The ratio can be positive or negative.

+5 SNR

-5 SNR

3

Examples:

- ▶ Signal is 60dB, noise is 40dB.
▶ S/N ratio is +20 (very good for speech)
- ▶ Signal is 60dB, noise is 70dB.
▶ S/N ratio is -10 (very poor for speech)
- ▶ Signal is 60dB, noise is 60dB.
▶ S/N ratio is 0 (do-able for adults; bad for children)



4

Noise:Summary

- ▶ Normal listeners do best with **positive** S/N ratios, but normal adults can listen well in situations involving negative S/N ratios.
- ▶ Children need **better** environments, should be positive. Trouble with negative S/N.
- ▶ **Children with atypical hearing need high positive ratios (+15 to +20 S/N) to learn in a classroom.**
- ▶ Noise sources:
 - ▶ **External** noise sources (outside the building)
 - ▶ **Internal** noise sources (within the building)
 - ▶ **Room** sources (within the room)
 - ▶ **People** sources (shuffling feet, talking, etc.)



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Research results: everyone is affected.

- ▶ Mean speech-recognition scores, in percent correct, of **adults with normal hearing** across various signal-to-noise ratios

Signal-to-noise ratio	Mean speech-recognition score (%)
Quiet	99.7%
+12	95.3%
+6	80.7%
0	46.0%

▶ From Finitzo-Hieber & Tillman, 1978

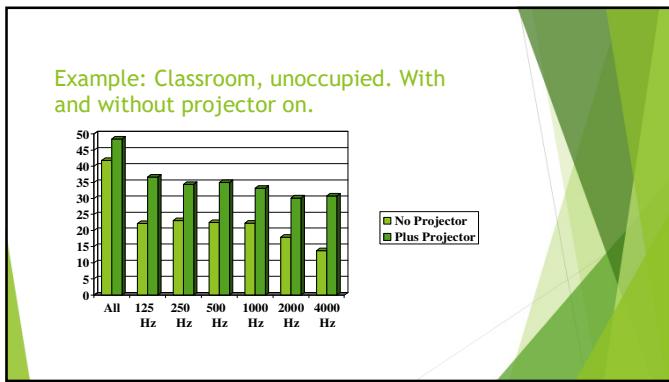


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Research results: there is a lot of noise everywhere.

- Unoccupied noise levels were 41dB(A). When the classroom was occupied with students, ambient noise levels increased to 56dB(A).
- Bess, Sinclair and Riggs (1984)

7



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Changes for listening environments:

1. Use assistive listening devices
2. Have speaker modify speech
3. Improve physical environment

9

Improve signal-to-noise ratio

- ▶ Preferential Seating
 - ▶ Close to teacher
 - ▶ Away from noise
 - ▶ Personal FM systems
 - ▶ Earbuds, earphones, earpiece
 - ▶ Soundfield FM systems
 - ▶ Single speaker, multiple speakers
 - ▶ Hearing devices
 - ▶ Hearing aids or PSAPS??
 - ▶ See: Hornickel, Zecker, Bradlow and Kraus (2012) "Assistive listening devices drive neural plasticity in children with dyslexia".
 - ▶ See: Kraus, Banai (2010) Listening, literacy and the neural transcription of sound.
 - ▶ See Cummins et al. (2001) Neurobiological responses to speech in language impaired children vs. healthy controls.



10

All remote microphone systems (FM systems) have, at a minimum,

- A **transmitter**: worn by speaker. The transmitter picks up the desired signal (which is acoustic energy) with a microphone, converts it to FM or digital signal, and sends it to the receiver.
 - A **receiver**: worn by listener. The receiver translates digital or FM signal back to acoustic energy and delivers the acoustic signal to the listeners ear.
 - Remote microphone systems have a limited range, but they are not confined by walls, etc.
 - In a situation, like a school, where multiple systems will be used simultaneously, each system has to transmit on a **different frequency**. If signals get mixed this is called "cross-talk". It is more economical to use a multi-frequency transmitter that can be changed as needed. The transmitter and receiver have to work on the same frequency.

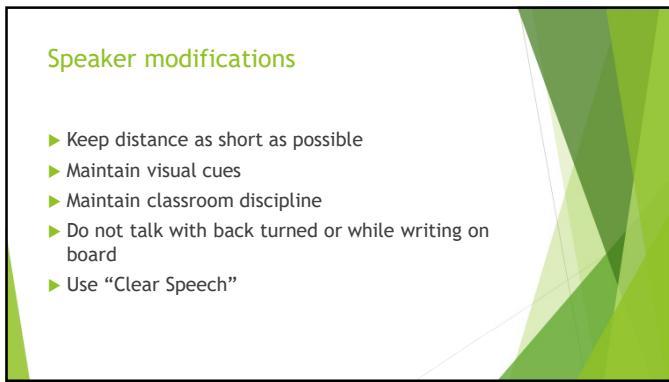
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Hearing Aids: goal is to mimic remote microphone system

- ▶ **Advantages:**
 - ▶ Child in charge of assistive listening device (rather than teacher)
 - ▶ Hearing aid microphones pick up all speakers, not just the speaker who has the remote microphone.
 - ▶ Can be used with other components (like remote microphone) to zero in on one talker if needed.
 - ▶ Maintenance and function monitored from home.
 - ▶ **Disadvantages:**
 - ▶ Expensive
 - ▶ Children tend to lose them.
 - ▶ Easier to purposefully sabotage.



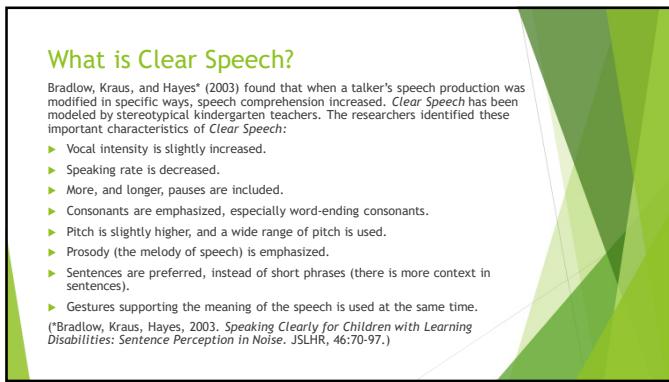
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Speaker modifications

- ▶ Keep distance as short as possible
- ▶ Maintain visual cues
- ▶ Maintain classroom discipline
- ▶ Do not talk with back turned or while writing on board
- ▶ Use “Clear Speech”

13



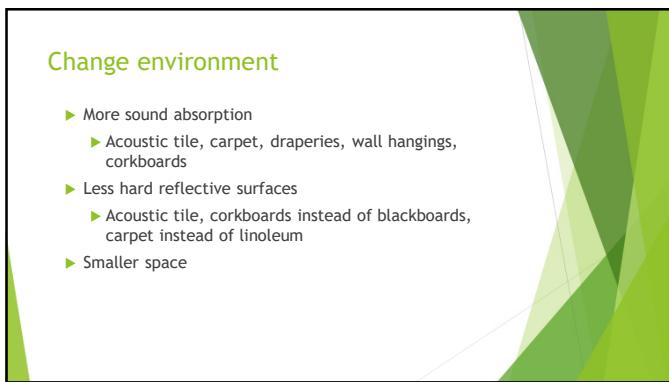
What is Clear Speech?

Bradlow, Kraus, and Hayes* (2003) found that when a talker's speech production was modified in specific ways, speech comprehension increased. *Clear Speech* has been modeled by stereotypical kindergarten teachers. The researchers identified these important characteristics of *Clear Speech*:

- ▶ Vocal intensity is slightly increased.
- ▶ Speaking rate is decreased.
- ▶ More, and longer, pauses are included.
- ▶ Consonants are emphasized, especially word-ending consonants.
- ▶ Pitch is slightly higher, and a wide range of pitch is used.
- ▶ Prosody (the melody of speech) is emphasized.
- ▶ Sentences are preferred, instead of short phrases (there is more context in sentences).
- ▶ Gestures supporting the meaning of the speech is used at the same time.

(*Bradlow, Kraus, Hayes, 2003. *Speaking Clearly for Children with Learning Disabilities: Sentence Perception in Noise*. JSLHR, 46:70-97.)

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Change environment

- ▶ More sound absorption
 - ▶ Acoustic tile, carpet, draperies, wall hangings, corkboards
- ▶ Less hard reflective surfaces
 - ▶ Acoustic tile, corkboards instead of blackboards, carpet instead of linoleum
- ▶ Smaller space

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