Perspective

Average Speech Levels and Spectra in Various Speaking/Listening Conditions: A Summary of the Pearson, Bennett, & Fidell (1977) Report

Wayne O. Olsen
Mayo Clinic, Rochester, MN

In 1977, Pearsons, Bennett, and Fidell completed a report for the U.S. Environmental Protection Agency describing their measurements of speech levels in a variety of settings. Their report, entitled *Speech Levels in Various Noise Environments,* Report No. EPA-600/1-77-025, was prepared for the Office of Health and Ecological Effects, Office of Research and Development, U.S. Environmental Protection Agency in Washington DC.

Pearsons, Bennett, and Fidell collected a unique yet large sample of data on background levels and the levels of conversational speech in schools, homes, hospitals, department stores, trains, and airplanes. Their data, therefore, provide vital information regarding speech levels and signal-to-noise (S/N) ratios encountered in "everyday" listening situations.

In addition, they measured speech levels and speech spectra of females, males, and children uttering a standard phrase at various vocal efforts in an anechoic chamber, thereby documenting differences in speech spectra related to gender, age, and vocal effort. The intent of this paper is to summarize their report and provide its important information to a larger segment of the professional community. Their measurements in everyday listening environments and in the anechoic chamber are treated separately in this summary.

Everyday Listening Situations

Method

Pearsons et al. (1977) completed measurements of speech levels of teachers in 20 classrooms, and for a "listener" in conversations with residents inside and outside 25 homes in urban and suburban areas, with patients and nurses in 23 locations in four hospitals, with personnel in seven large department stores, with 11 passengers on the Bay Area Transport trains in San Francisco, and with 12 passengers in four commercial jet aircraft and one commercial propeller-type airplane.

In the classroom setting, the teachers' speech was recorded at a lavaliere microphone worn by each teacher and with microphones at a distance of 2 m (near the front of the classroom) and a distance of 7 m (at the back of the classroom). Measurements from the lavaliere microphone were mathematically adjusted (i.e., normalized) to levels equivalent to those that would have been observed at a distance of 1 m.

For measurements in the home settings, hospitals, department stores, trains, and airplanes, recordings were made for the listener, who wore a microphone near the ear in an eyeglass frame. Several segments of continuous conversation at least 10 s in length by the "talker," that is, without responses by the "listener," were recorded. The distance between the talker and the listener generally was 1 m—a distance voluntarily selected in the home environment as a "usual" communication distance. In the train and airplane settings, the distance between the talker and listener was approximately 0.5 m. Also, recordings were completed for the background noise levels when there was no conversation between the participants.

Recordings were analyzed with a real-time one-third octave analysis system. Levels of the speech and background noise were given in A-weighted sound pressure levels. The integration time on the analyzer was equivalent to "fast" on sound-level meters.

Results

The means and standard deviations for the background noise and teachers' speech levels while lecturing are provided in Table 1. Mean background levels in the two schools were 48 and 51 dBA; mean speech levels near the front of the classroom (2 m) were 62 and 66 dBA, for schools 1 and 2, respectively, maintaining a S/N ratio on the order of +15 dB. The speech level near the back of the classroom (7 m) was approximately 5 dB weaker. The authors also reported that, normalized at a distance of 1 m,

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TABLE 1. Mean speech and background levels in dBA for 20 classrooms in two schools. Standard deviations in ( ).

	Background Noise	Speech 1 m	Speech 2 m	Speech 7 m
School #1	48 (2)	69 (4)	62 (5)	57 (4)
School #2	51 (2)	73 (4)	66 (5)	62 (6)

Note. All values are rounded to the nearest dB. From Table II in Pearsons et al. (1977).

the teachers' speech levels increased approximately 1 dB for each dB increase in noise level from 45 dBA to 55 dBA.

The average noise levels outside and inside urban homes were 61 and 48 dBA, respectively; for suburban homes, the levels were 48 and 41 dBA, outside and inside, respectively (see Table 2). Average speech levels (normalized to 1 m) were 65 dBA outdoors and 57 dBA indoors for urban homes. The average speech levels were 55 dBA both inside and outside for suburban homes. The S/N ratios at conversation distances were on the order of +5 dB and +9 dB outside and inside, respectively, for urban homes, and +8 dB and +14 dB for like settings in suburban areas. Pearsons et al. (1977) also noted that the level of speech from the television averaged 61 dBA at the listener's ear, which was usually approximately 3 m from its loudspeaker.

At conversation distances in hospital settings, speech averaged 55 dBA in patients' rooms and 57 dBA in the nurses' stations (Table 3). Noise levels were 45 dBA in the former and 52 dBA in the latter. Apparently, the talkers adjusted their speech levels only minimally when moving from the patients' rooms to the nurses' stations, despite the 7 dB higher noise level at the nurses' stations. The S/N ratio was +10 dB in the patients' rooms and +5 dB in the nurses' stations at conversation distances.

TABLE 2. Mean speech and background levels in dBA, indoors and outdoors, for urban and suburban homes. Standard deviations in ( ).

	Background Noise		Speech 1 m		Speech Conversation Distance	
	Urban	Suburban	Urban	Suburban	Urban	Suburban
Outside	61 (5	48 (4)	65 (4)	55 (5)	66 (4)	5 (5)
Inside	48 (2)	41 (3)	57 (6)	55 (5)	57 (6)	55 (5)

Note. All values are rounded to the nearest dB. From Table II in Pearsons et al. (1977).

TABLE 3. Mean speech and background levels in dBA in hospitals and department stores. Standard deviations in ( ).

	Background Noise	Speech 1 m	Speech Conversation Distance
Hosp. Patient's Room	45 (2)	56 (2)	55 (1)
Hosp. Nurses' Station	52 (5)	56 (3)	57 (4)
Department Store	54 (3)	58 (3)	61 (3)

Note. All values are rounded to the nearest dB. From Table II in Pearsons et al. (1977).

In the department stores, the average background noise was slightly greater, 54 dBA. Normalized to 1 m, the speech level was 58 dBA, but the communication distance was somewhat closer in that setting, resulting in an overall level of 61 dBA at the listener's ear. The S/N ratio was approximately +7 dB at usual conversation distances.

Noise levels were considerably higher in the trains and airplanes, 74 and 79 dBA, respectively (Table 4). The conversation distance in these situations was 0.4 m, and the average speech levels at this distance were 73 dBA in the trains and 77 dBA in the airplanes. Hence, the S/N ratios were -1 and -2 dB in these situations.

Anechoic Chamber Measurements

Method

Speech levels were measured in an anechoic chamber for 100 individuals speaking at levels ranging from casual conversation to shouting at a distance of 1 m. The phrase, "Joe took father's shoe bench out; she was waiting at my lawn" was uttered by females, males, and children. They were instructed to repeat the desired phrase at "normal," "raised," "loud," and "shouted" levels. In addition, recordings were made of casual conversation at a distance of 1 m in the anechoic chamber.

TABLE 4. Mean speech and background levels in dBA in trains and airplanes. Standard deviations in ( ).

	Background Noise	Speech 1 m	Speech Conversation Distance
Train	74 (3)	66 (2)	73 (3)
Airplanes	79 (3)	68 (4)	77 (4)

Note. All values are rounded to the nearest dB. From Table II in Pearsons et al. (1977).

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Again, the recordings were analyzed with a real-time one-third octave analysis system. Both A-weighted and overall sound pressure levels were determined. For the one-third octave analysis, 100 samples at 0.1 s intervals were taken. The integration time was equal to "fast" on sound-level meters.

Results

A summary of the speech levels observed for females and males aged 13 to 60 years and for children under age 13 for different vocal efforts is provided in Table 5. Overall (unweighted) and A-weighted sound pressure levels and standard deviations are included. The differences between A-weighted and unweighted sound pressure levels were 3 dB to 4 dB for casual speech and for normal speech, 2 dB to 3 dB for raised speech, 1 dB for loud speech, and 0 dB for shouted speech for the three groups of talkers.

Casual speech during conversation was approximately 5 dB weaker than normal vocal effort for the phrase "Joe took father's shoe bench out; she was waiting at my lawn." Raised speech was approximately 7 dB more intense than normal speech, and loud speech was elevated by another 11 dB by the males and 8 dB to 9 dB by the females and children.

TABLE 5. Mean speech levels in dBA and unweighted sound pressure levels for casual, normal, raised, loud, and shouted speech by males, females, and children in an anechoic chamber. Unweighted sound pressure levels in [ ]. Standard deviations in ( ).

	Casual	Normal	Raised	Loud	Shouted
Females	50 [54] (4)	55 [58] (4)	63 [65] (4)	71 [72] (6)	82 [82] (7)
Males	52 [56] (4)	58 [61] (4)	65 [68] (5)	76 [77] (6)	89 [89] (7)
Children	53 [56] (5)	58 [61] (5)	65 [67] (7)	74 [75] (9)	82 [82] (9)

Note. All values are rounded to the nearest dB. From Table I and Figures 16, 17, and 18 in Pearsons et al. (1977).

Shouted speech increased by an additional 8 dB to 13 dB across the three groups.

Table 6 and Figure 1 (a through e) show the one-third octave speech spectra for the three groups of talkers speaking at levels ranging from casual to shouted in the anechoic chamber. The data in Table 6 are arranged by talkers for comparison of levels as vocal effort increased from casual to shouted for each group. The plots in Figure 1 are organized by vocal effort for comparison of speech spectra across talkers at each vocal effort.

The speech spectrum for the males revealed more energy at 125 Hz, but from 250 Hz through 8000 Hz, the speech spectra were similar for the three groups for casual

TABLE 6. Mean sound pressure levels in one-third octave bands for speech at five vocal efforts by three groups of talkers.

	Frequency																		
Vocal Effort	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000
Females																			
Casual	26	36	47	44	39	45	45	44	39	36	36	36	35	31	30	30	30	32	33
Normal	26	37	48	47	42	49	50	48	46	42	43	42	38	36	38	40	36	36	34
Raised	25	35	48	53	49	53	57	55	54	52	53	52	47	45	45	45	42	40	39
Loud	20	34	45	55	55	55	59	62	62	61	62	62	57	54	53	53	49	47	45
Shouted	20	30	40	50	55	61	64	68	70	72	74	74	70	67	67	64	60	57	55
Males																			
Casual	44	42	46	46	44	47	48	45	38	37	39	39	35	33	33	35	34	33	32
Normal	48	43	48	52	51	53	54	52	46	45	47	44	40	41	41	38	34	35	32
Raised	51	49	51	56	55	58	60	58	54	53	54	51	47	47	46	44	40	41	38
Loud	50	55	57	60	62	65	68	69	66	65	67	64	59	59	57	55	49	48	46
Shouted	42	42	57	66	68	69	74	78	78	78	80	78	73	72	70	68	62	61	59
Children																			
Casual	23	25	42	47	39	43	49	48	43	39	37	38	38	33	33	33	33	33	33
Normal	24	29	42	51	47	47	53	52	49	44	43	43	41	38	39	40	38	36	37
Raised	25	30	41	51	54	53	55	58	57	54	54	54	50	46	47	48	45	43	43
Loud	24	29	41	51	54	58	60	60	63	61	62	63	60	54	54	54	52	49	48
Shouted	24	45	43	49	53	61	66	66	67	72	72	72	71	65	66	66	63	57	54

Note. All values are rounded to the nearest dB. Derived from Figures 16, 17, and 18 in Pearsons et al. (1977).

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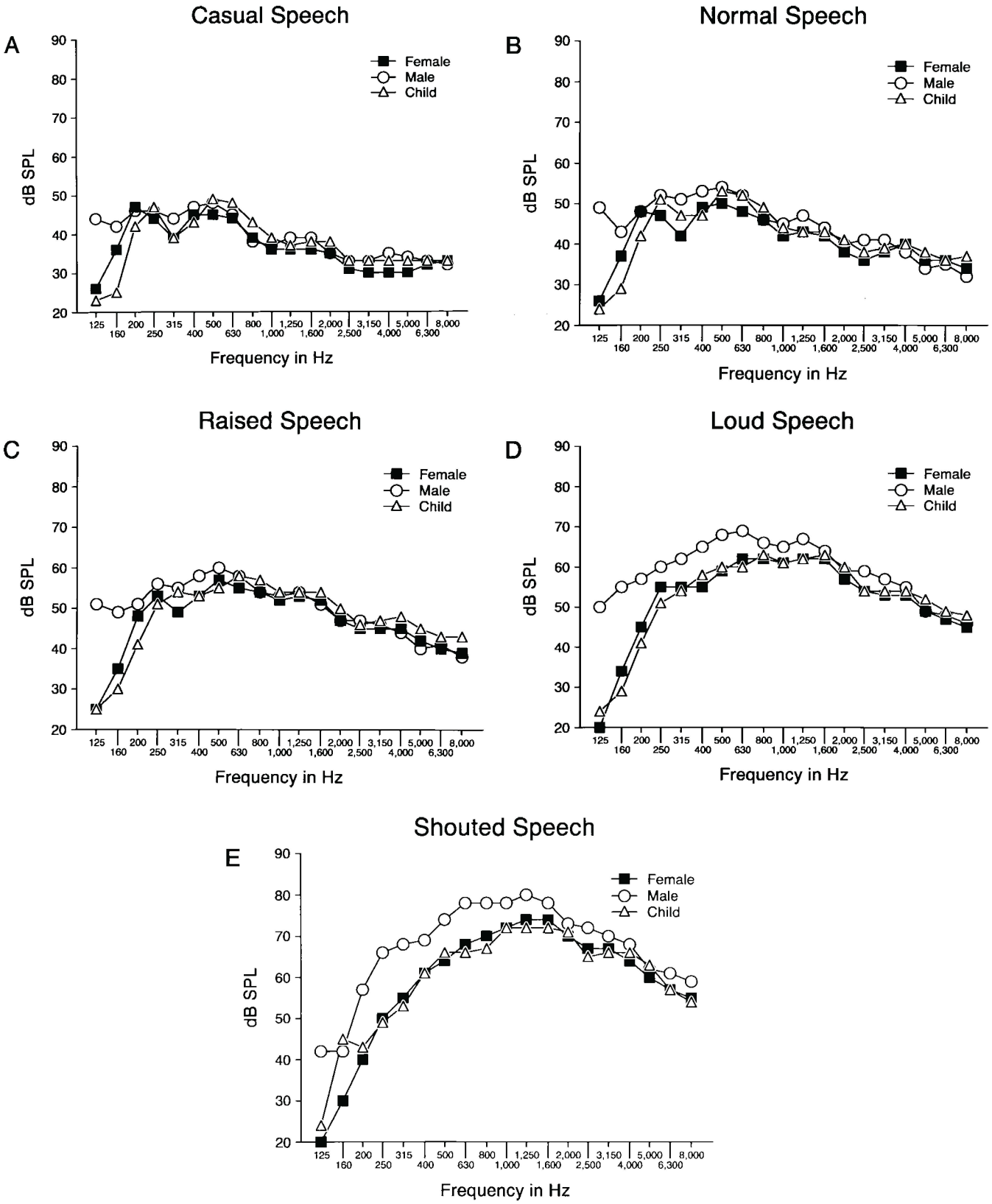
FIGURE 1. Speech spectra for females, males, and children for casual conversation (A), for normal vocal effort (B), for raised speech (C), for loud speech (D), and for shouted speech (E) as measured by Pearsons et al. (Adapted from figures 16, 17, and 18 in Pearsons et al., 1977).



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conversation and for normal and raised vocal efforts. For loud and shouted speech, the spectra for children and for females were similar. Male speech spectra at these levels had considerably more energy, at least through 1250 Hz and 1600 Hz for loud and shouted speech, respectively. Also, a shift in the maximum one-third octave band was apparent for the loud and shouted speech spectra, rising to 630 Hz for loud speech and to 1250 Hz for shouted male speech. Spectra for the females and children showed a plateau from 800 to 1600 Hz for loud speech and from 1000 to 1600 Hz for their shouted speech.

Summary

The large study undertaken by Pearsons et al. (1977) for the Environmental Protection Agency nicely demonstrates "usual" speech levels in a variety of settings in classrooms, homes, hospitals, department stores, and commercial transportation. In most settings, speech levels were between 55 and 66 dBA at conversation distances in the school, home, hospital, and department store environments. S/N ratios on the order of 5 to 15 dB were maintained.

Communication distance in the trains and airplanes was considerably less than the usual 1 m, and the speech levels were higher, 73 to 77 dBA, but still at a -1 or -2 dB S/N ratio in the train and airplanes, respectively. Their measurements in an anechoic chamber further reflected the levels of conversational speech in a quiet environment, as well as the levels and spectra for different vocal efforts by females, males, and children. Speech spectra were generally similar for the groups of talkers for casual conversation through raised vocal efforts. For loud speech, and particularly for shouted speech, male speech levels were greater than the speech levels of the females and children. The maximum one-third octave bands for loud and shouted speech shifted to higher frequencies for all three groups.

Reference

Pearsons, K. S., Bennett, R. L., & Fidell, S. (1977). *Speech levels in various noise environments* (Report No. EPA-600/1-77-025). Washington, DC: U.S. Environmental Protection Agency.

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Contact author: Wayne O. Olsen, Section of Audiology, Mayo Clinic, Rochester, MN 55905

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