

Typical speech exposure during fetal neurodevelopment

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Introduction

There are many factors that influence language acquisition in young children, potentially affecting their language abilities later in life. The fetal auditory system responds to extrauterine acoustic stimuli, presumably nurturing auditory neurodevelopment while *in utero*. Although it has been shown that fetal auditory exposures during the third trimester can shape neural responses to speech and language for newborns, we have yet to determine if and how the prenatal auditory experience impacts speech and language development later in life.

To begin examination of these questions, we collected and analyzed daily fetal speech exposure data for speech generated in the extrauterine environment.

Fetal hearing

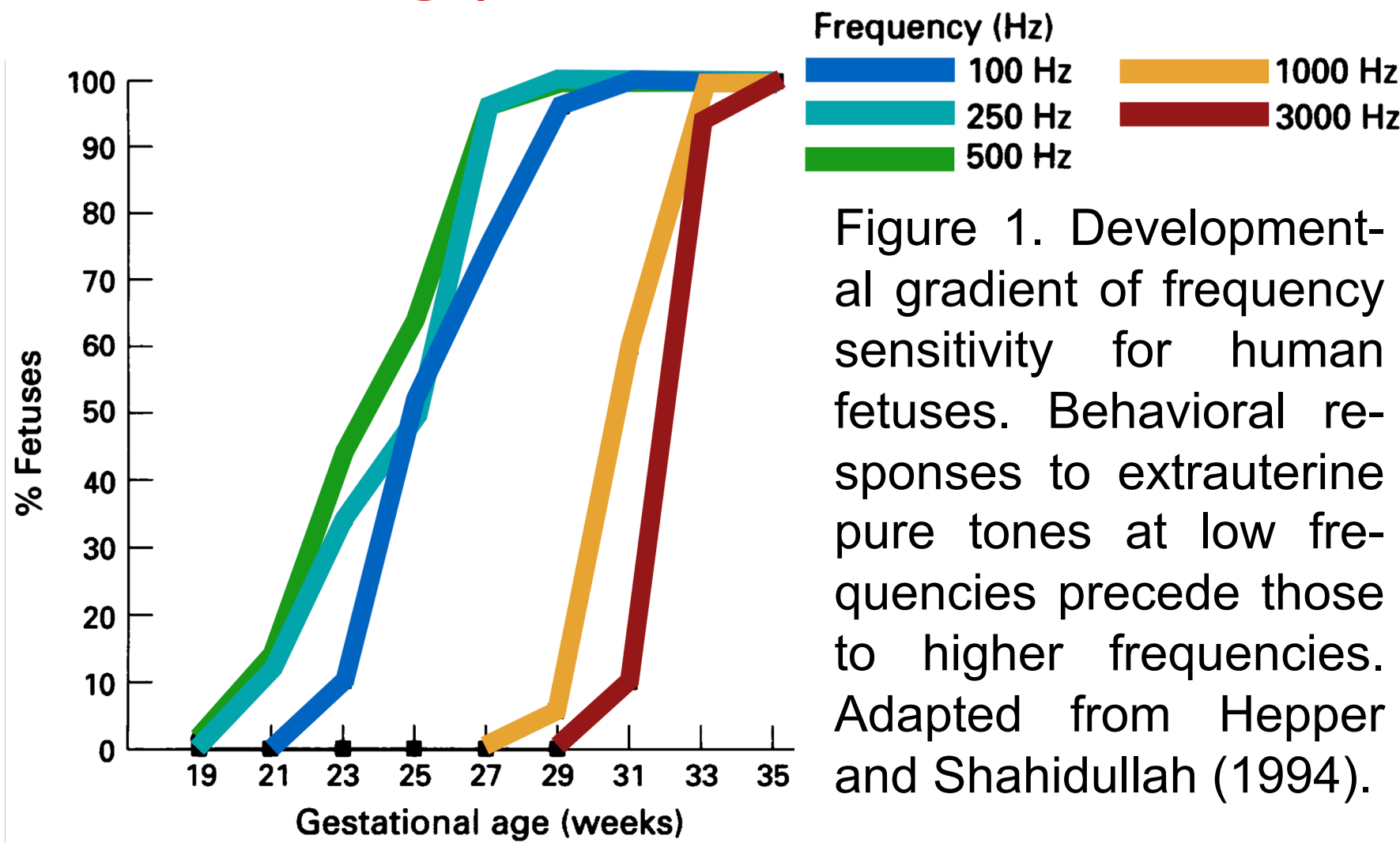


Humans are altricial mammals with precocial hearing. Fetuses display reliable behavioral responses to extrauterine acoustic stimuli as early as 23 weeks' gestation (Figure 1). What are fetuses hearing?

The prenatal acoustic environment is unique, dominated by mother's cardiovascular, vocal, and digestive sounds transmitted *via* amniotic fluid. Also present are the sounds of extrauterine vocalizations, music, and other sounds that impinge on the abdomen of the mother. Full-term newborns display behavioral and neurophysiological responses that distinguish between acoustic stimuli to which they were exposed *in utero* and novel stimuli. For example, prenatal learning has been demonstrated for mother's voice, mother's native language, frequently heard speech passages, individual phonemes, speech prosodic features, and music.

Prenatal hearing and auditory learning is facilitated by an auditory neural pathway mature enough to permit cochlear input to reach at least primary and nonprimary auditory cortical regions.

Fetal hearing (continued)



The abdomen wall provides some attenuation of extrauterine sound into the intrauterine environment, but not as much as is generally believed. Maximum attenuation is $\leq \sim 15$ dB at the highest frequencies (Figure 2). Extrauterine speech is audible and fairly intelligible.

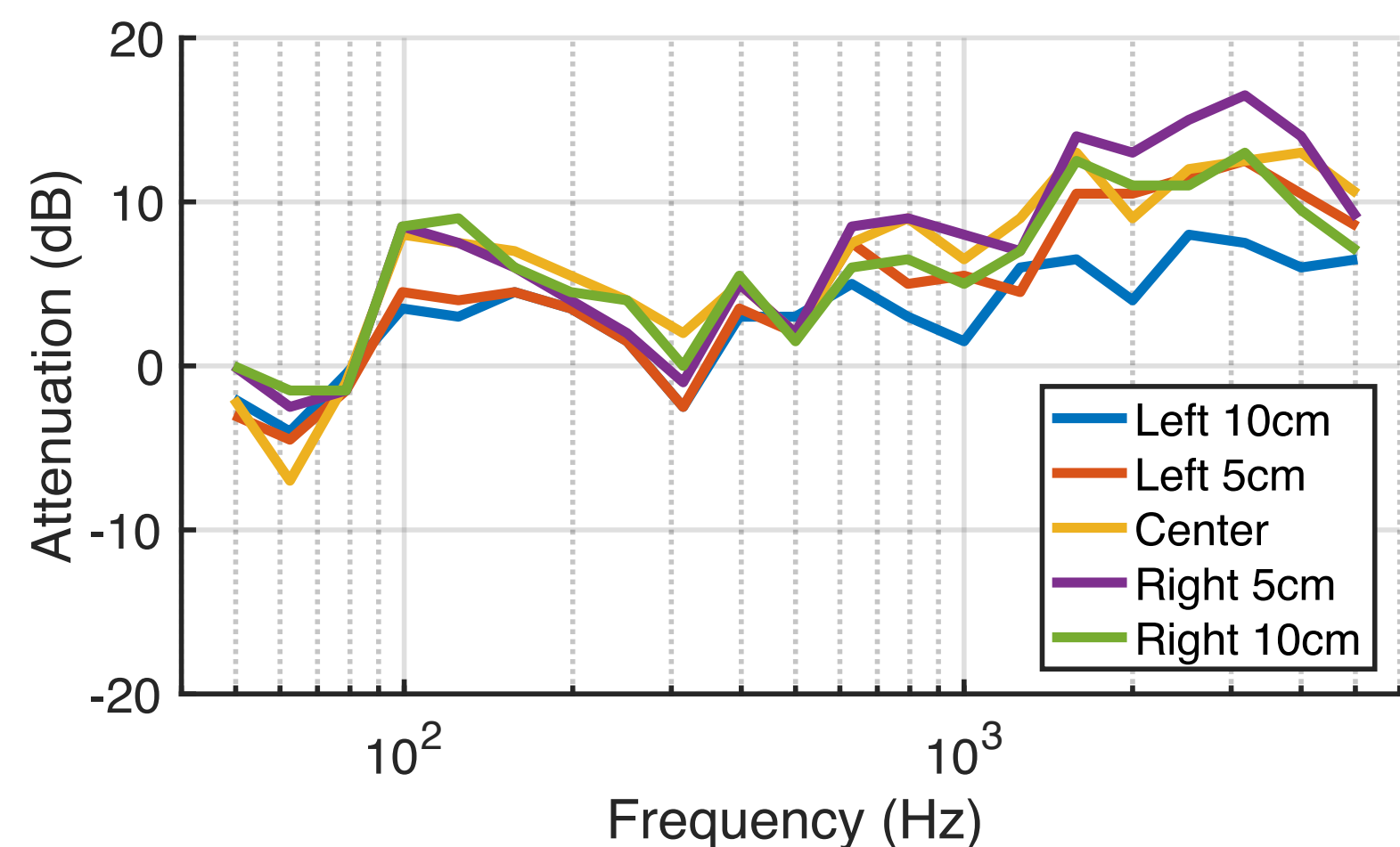


Figure 2. Transfer function across the abdomen wall of a pregnant sheep. Attenuation was measured using a hydrophone implanted at multiple locations in the uterus of a pregnant ewe. Adapted from Peters et al (1993).

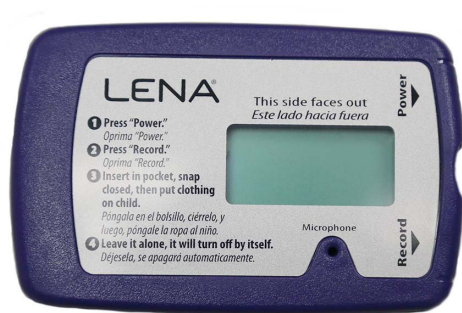
Aim

To quantify typical speech and language exposure for developing fetuses

Method

Recordings:

- LENA audio recorders
- 24-hr audio recordings, 16-kHz sampling rate
- Automated classification of durations of different sound categories: nearby speech, distant speech, total speech, electronic sounds, noise, silence



Method (continued)

Subjects and Procedure:

- 12 pregnant women with healthy pregnancies
- Between 20 and 32 weeks pregnant at time of enrollment
- Device worn in LENA-compliant pouch around the neck (Figure 3)
- Recordings made 2x per week until delivery
- Device placed at bedside during sleep to capture “silence”
- Removal of device > 5 minutes documented *via* text message to the research team
- Weekly alternating recording schedule (M/W/F or Tu/Th/S); participant chooses two days out of three options
- Subject occupations:



Figure 3. Pregnant mother wearing LENA device in a pouch around the neck.

Sub.	Occupation	Sub.	Occupation
1	Clinician (days off only)	7	Hydrologist
2	Health office	8	Accountant
3	Library worker	9	Stay-at-home mother
4	Library worker	10	Professor
5	Clinician (days off only)	11	Unemployed
6	Professor	12	Education office

Results

- > 6800 hrs of total data
- Average # of recordings per subject:
 - 24 recordings (12 weeks)
- Average total daily speech exposure:
 - 4.5 hrs \pm 0.94 hrs
 - Range: 3 – 6 hrs

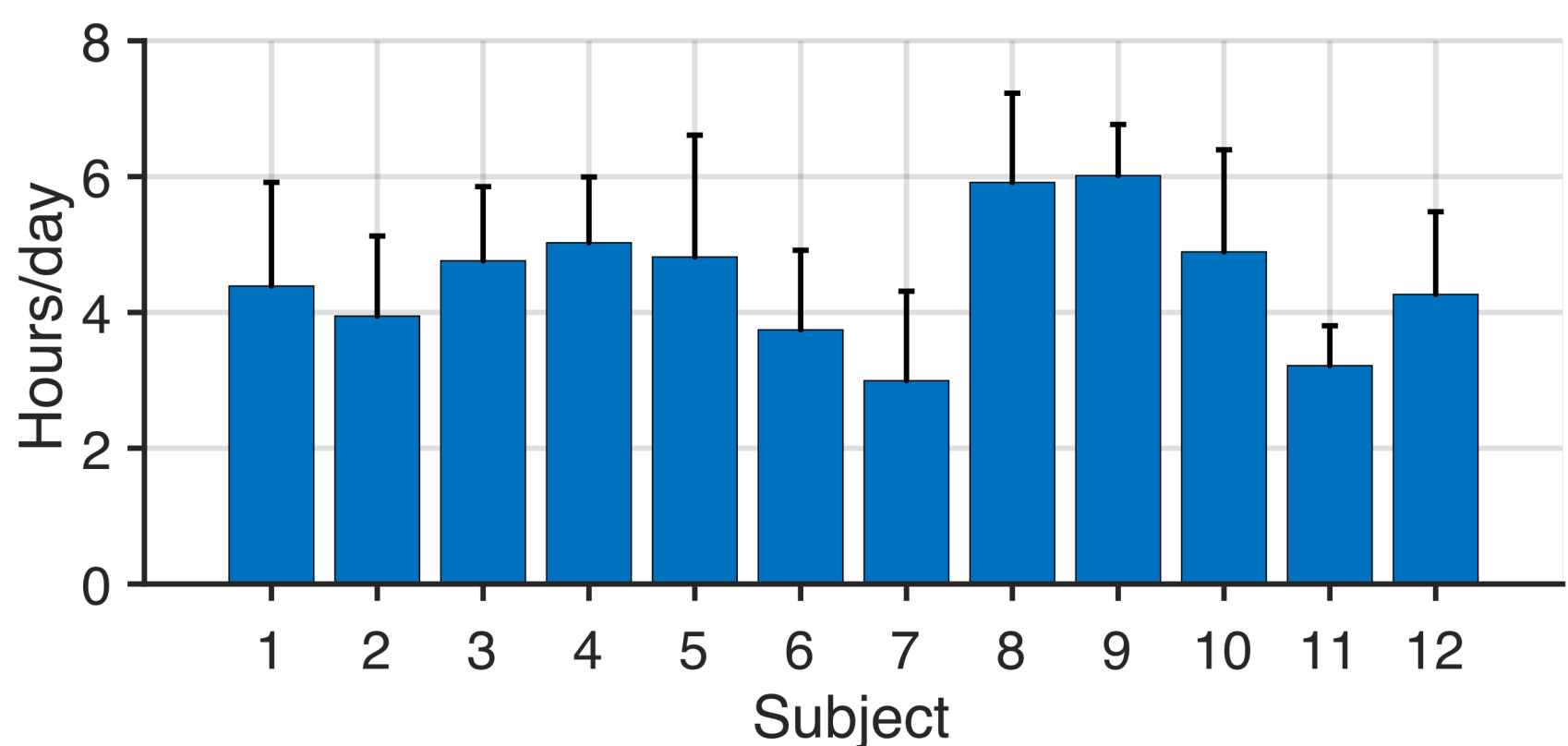


Figure 4. Average daily speech exposure for each subject.

Results (continued)

- Average total daily adult word count:
 - 25.0 k \pm 5.8 k words
 - Range: 14.8 k – 36.5 k

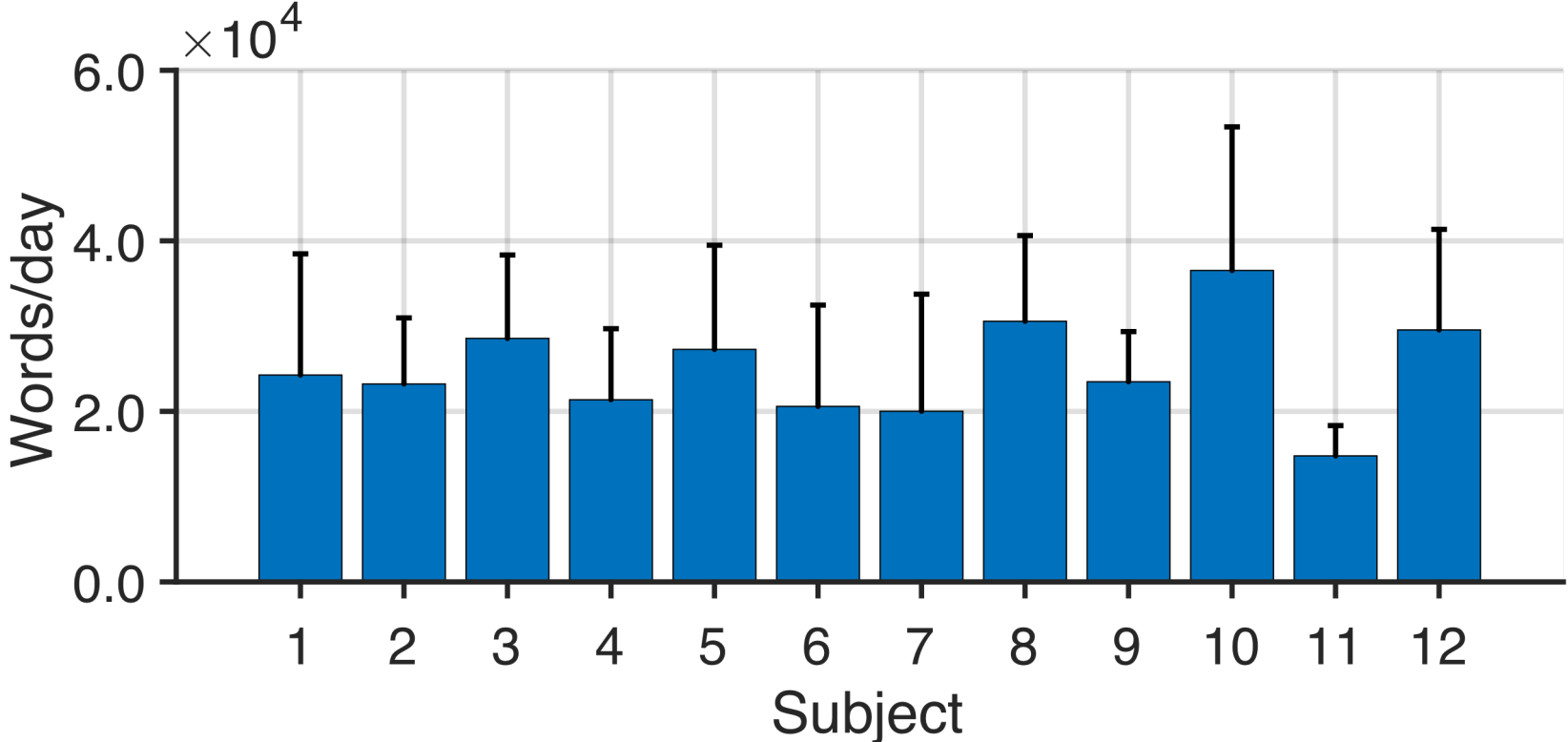


Figure 5. Average daily adult word count for each subject.

Conclusions

- Typical speech exposure for fetuses is 4-5 hrs per day
- Substantial within- and between-subject variability
- Some newborns are born with only 50% of the speech/language exposure of their peers
 - Holds true for both *duration* of speech exposure and *total words*
- Limitations: Only 2x/week sampling; some occupations inconducive to audio recordings
- Data collection is ongoing, including ABRs at age 3 months' follow-up

References

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