Daylong acoustic amplitude from the perspective of young children with and without hearing loss

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Research questions

1. **Is the daylong acoustic environment louder for boys than for girls?**
2. **Is the daylong acoustic environment louder for children who are typically developing (TD) than for children who are hard-of-hearing (HH)?**
3. **What role do age and hearing loss have on the daylong acoustic environment?**

Background

Language development is dependent on exposure to language (Thomas, Forrester, & Ronald, 2013). The acoustic characteristics of the auditory environment matter for language development. One acoustic measure that is a key factor for speech perception is signal-to-noise ratio (SNR). One application of SNR is in the amplitude domain: greater amplitude may indicate greater SNR.

Sentence recognition decreases and listening effort increases as SNR decreases (Lewis et al., 2016). This is of particular importance for HH children who have limited or degraded access to the acoustic signal (Shapiro, Hurry, Masterson, Wydell, & Doctor, 2009). It has also been demonstrated that the decrement in performance for HH children is greater than for TD children as the SNR decreases (Crandell, 1993), and differences in HH children may have developmental, physiological, and social consequences (Hicks & Tharpe, 2002).

Little is known about the acoustic characteristics of the daylong auditory environment of children, regardless of hearing status. This work looks at the daylong acoustic amplitude from the auditory perspective of young TD and HH children.

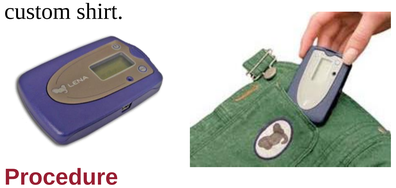
Method

Participants

85 children and their families participated, including families of 42 boys and 43 girls from 0-90 months of age. 33 (39%) were TD and 52 (61%) were HH, ranging from mild to profound. Data were collected from the *Cougar Corpus* (VanDam, 2017) which is part of the HomeBank project (`http://homebank.talkbank.org/`)

Materials

Raw audio was collected using the LENA system (LENA Research Foundation, Boulder, CO). The LENA is a continuous, daylong audio recorder worn in a pocket on the front of a custom shirt.



Procedure

Daylong audio recordings were collected in a naturalistic setting from the audio perspective of the child. Each family contributed an average of 9.5 days. 814 daylong recordings were collected totaling 9362.5 hours of audio (29 additional recordings were excluded due to technical problems). 316 recordings were from TD children and 496 from HH children. 382 of the recordings were from boys and 432 were from girls.

Data analysis, statistics

To obtain daylong amplitude values, root mean square (RMS) amplitude from each daylong WAV file was collected. RMS amplitude was then converted to decibels sound pressure level (dB SPL). Data were analyzed using two-tailed *t*-tests and Pearson correlations. Linear least squares regressions are shown in Figure 4.

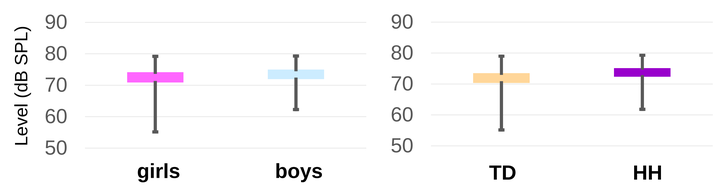


Fig. 1. **Mean dB SPL for boys and girls.**

Fig. 2. **Mean dB SPL for TD and HH.**

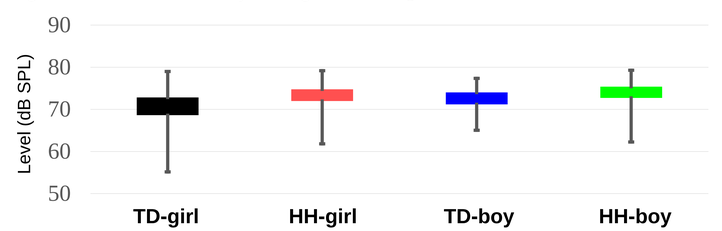


Fig. 3. **Average dB SPL in girls' and boys' recordings with and without hearing loss.**

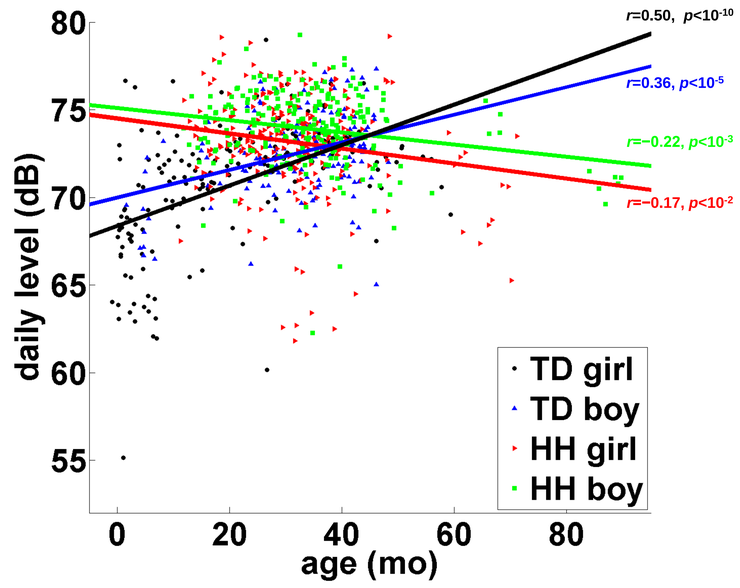


Fig. 4. **Average dB SPL for TD and HH girls and boys as a function of age.**

Results

1. **Boys' recordings had a higher amplitude than girls' recordings (t=-9.2, p<10^{-18}). See *Fig 1.***
2. **Families of HH children had a higher amplitude than families of TD children (t=-5.67, p<10^{-7}). See *Fig. 2.***
3. **For recordings from families of HH children amplitude was negatively correlated with age ($r_{♀}$=-0.17, males $r_{♂}$=-0.22), but for families of TD children amplitude was positively correlated with age ($r_{♀}$=0.50, $r_{♂}$=0.36). See *Fig. 4.***

Discussion

HH children have made many important gains in a variety of domains (Moeller, 2000). The interaction effect between age and hearing status has not been shown before. The developmental trajectories (*Fig. 4*) appear to cross at about 40 months. This age-related effect may be partially explained by the advent of Theory of Mind (ToM) or preliteracy skills that emerge around 40 months. ToM and literacy are dependent on language development, which is heavily influenced by acoustic input (Moeller & Schick, 2006). ToM has been found to be delayed in children who are deaf and hard of hearing (Milligan, Astington, & Dack, 2007) and more generally in children with disorders (Peterson & Siegal, 1999). Preliteracy skills have also been shown to be delayed in children with HL (Moeller, 2007). One study found literacy tasks were negatively correlated with age in children with HL (Easterbrooks, Lederberg, Miller, Bergeron, & Connor, 2008).

Future directions

1. Look at daylong amplitude of speech productions by specific interlocutor/family members. Mothers, fathers, and children may contribute differently to the acoustic environment.
2. Look into other acoustic factors known to influence speech development and how those factors may interact with amplitude. Some of those factors include temporal characteristics, fundamental frequency, and spectral shape of the acoustic environment.
3. Explore external factors that may influence overall amplitude such as number and relative ages of siblings, role of caregivers, socio-economic factors, cultural influence, or comorbid conditions.

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For raw data and to download the acoustic WAV files, go to `http://homebank.talkbank.org/`.

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