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

Mark VanDam1,3, Haille N. Heid1, Steven James2, Samantha Schraven3, Danette Driscoll5, Amy Hardie3, Stacy Cahill3, & Daniel Olds1

1Speech & Hearing Sciences, Elson S. Floyd College of Medicine, Washington State University
2Medical Education and Clinical Sciences, Elson S. Floyd College of Medicine, Washington State University
3Hearing Oral Program of Excellence (HOPE)

174th meeting of the Acoustical Society of America, New Orleans, LA | December 6, 2017

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, Foster, & 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 in the auditory environment 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 auditory 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 days). 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 1.

Results
1. Boys’ recordings had a higher amplitude than girls’ recordings (t = 5.2, p < 0.01). See Fig. 1.
2. Families of HH children had a higher amplitude than families of TD children (t = 5.67, p < 0.01). See Fig. 2.
3. For recordings from families of HH children amplitude was negatively correlated with age (r = -0.41, max r = -0.52), but for families of TD children amplitude was positively correlated with age (r = 0.30, r = 0.56). 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 correlated effect may partially explain 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 & Schiik, 2006). ToM has been found to be delayed in children who are deaf and hard of hearing (Milligan, Astonington, & Duck, 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, 2008).

Future directions
1. Look at daylong amplitude of speech productions by specific interlocutors/family members. Mothers, fathers, and children can 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 signal.
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.

References


For raw data and to download the acoustic WAV files, go to http://homebank.talkbank.org/. Work supported by The Washington Research Foundation and NSF-SBE RIDIR-1539133