Preliminary Study on Fundamental Frequency of Child and Adult in Natural Home Environment

Dongxin Xu[1], John Hansen[2], Jeffrey A. Richards[1], Jill Gilkerson[1]

[1]LENA Foundation, Boulder, Colorado, USA

[2]Center for Robust Speech Systems, University of Texas at Dallas, Richardson, Texas, USA

Introduction

Fundamental Frequency (F0) or Pitch of human voice is an important aspect in human verbal communication. It is related to prosody and intonation, conveying information of questioning, affirmation, denying and general emotion. In some languages like Chinese, the trend of F0 can even distinguish words. F0 is an important research topic. 2010 International Meeting for Autism Research has presentations [1] [2] reporting that children with autism exhibit higher elevation and larger variation in F0 compared with children of typical development. The results are based on laboratory data. It would be interesting to study the statistics of F0 using LENA natural home environment data. Furthermore, LENA data contains adult speech in natural home environment during their interaction with children or among themselves. The investigation of these data will enhance our understanding from one particular angle on child development and how environment can impact on it, and even how child development can conversely influence adult behavior.

References

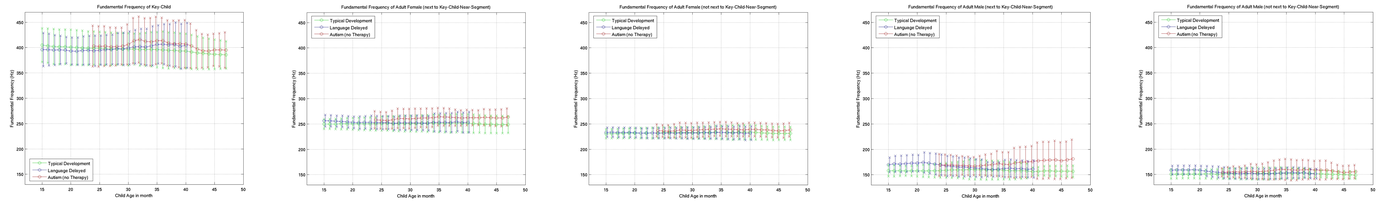
[1] Y. S. Bonneh, Y. Levanon, O. Dean-Pardo, "Increased Pitch Variability in Young Autistic Children", 2010 International Meeting for Autism Research, Philadelphia, May 20-22, 2010

[2] M. Sharda, N. Singh, "Sounds of Melody—Acoustic Features of Speech in Autism", 2010 International Meeting for Autism Research, Philadelphia, May 20-22, 2010

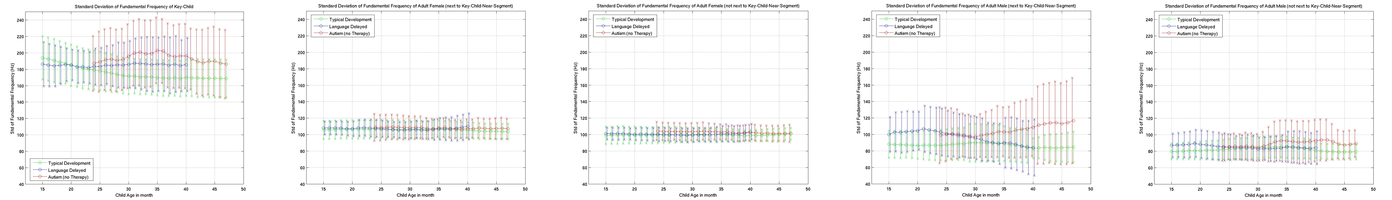
[3] D. Oller, P. Niyogi, S. Gray, J. Richards, J. Gilkerson, D. Xu, U. Yapanel, S. Warren. "Automated Vocal Analysis of Naturalistic Recordings from Children with Autism, Language Delay and Typical Development," Proceedings of the National Academy of Sciences of the United States of America, Vol 107, No. 30, pp. 13354-13359, published online July 27, 2010.

[4] D. Xu, U. Yapanel, S. Gray, J. Gilkerson, J. Richards, J. Hansen. "Signal Processing for Young Child Speech Language Development," 1st Workshop on Child, Computer and Interaction, Oct. 2008, Chania, Crete, Greece.

Fundamental Frequency, Range Comparison



Standard Deviation of Fundamental Frequency, Range Comparison



Data

LENA data contains daylong recordings for children with typical development (TD), language delay (LD) and autism (ASD) (refer to 2010 July PNAS paper [3]). The TD group has 106 children with 802 recordings; the LD group has 49 children with 333 recordings. The ASD group has recordings with/without therapy. The recordings containing therapy time are excluded from the study because therapy may affect both child and adult's F0 and should be studied separately. The ASD group without therapy has 71 children with 228 recordings.

Method

All recording are automatically segmented into categories of Key-Child, Other-Child, Adult-Female, Adult-Male, Noise, Silence, Overlapped-Sounds and TV/Electronic Media. These segments are further classified as near/far (or clear/faint). In this study, Key-Child-Near segments are processed to obtain F0 for children. Adult-Female-Near segments are divided into two groups depending on whether they are next to Key-Child-Near segments or not. It is believed that if an adult segment is next to a Key-Child segment, the adult speech is directed to the child. This way, adult behavior such as motherese can be studied. Adult-Male-Near segments are processed and analyzed in the same way as Adult-Female-Near ones.

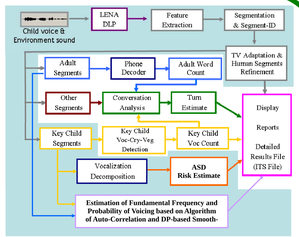
The LENA Framework

Daylong audio recordings are collected by having the child wear a lightweight digital recorder. Audio data is automatically segmented into a sequence of eight sound categories: Key-Child, Other-Child, Adult-Male, Adult-Female, Overlap, Noise, Silence, and TV/Electronic Media. Non-silence categories are further divided by likelihood tests into clear/faint sub-categories (in an approximation to near/far categories.)

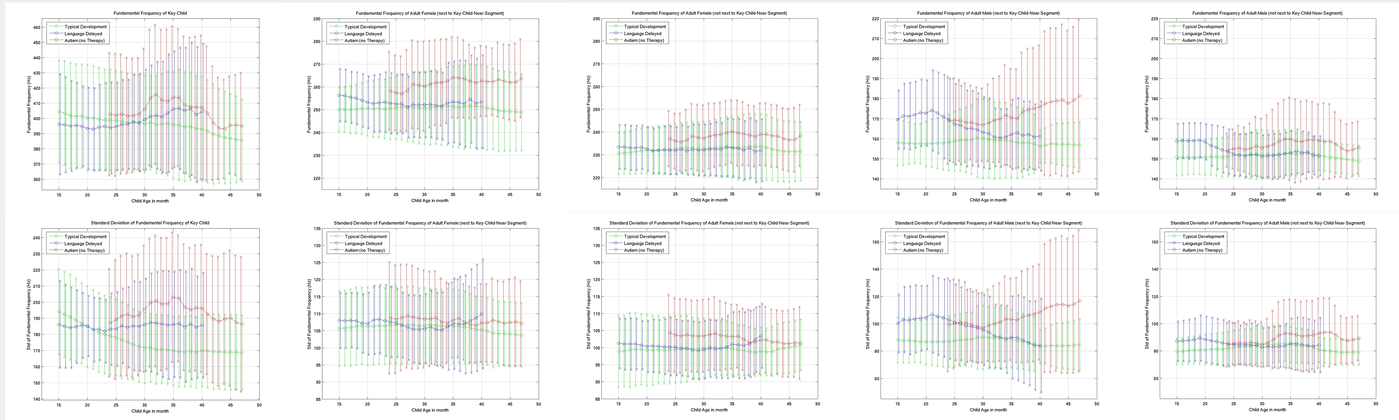
Turn on the DLP and replace it in the pocket of the child's LENA clothing at the beginning of the recording session (when the child wakes up in the morning typically).

At the end of the recording session, plug the LENA DLP into a Windows-based computer. The software automatically uploads and processes the audio recording file.

The processing results can be generated in different formats. The resolution of the reports can be by second, minute, hour, day, etc., or by sound segments.



- Monitoring of Child Development and the Natural Child Environment
- Data Collection and Analysis for Research, Clinical Use and Parenting Feedback
- Intervention Tool for Children with Language-related Disorders



Conclusion

As shown in the graphs, horizontal axis is the child age in month; vertical axis is either F0 or its standard deviation. Each vertical bar shows one standard deviation range. From the graphs, we can preliminarily conclude: 1. children with ASD have higher F0 elevation and larger F0 variation, consistent with what reported in 2010-IMFAR; 2. Children of TD slightly lower their average F0 when they grow; their F0 variation drops significantly with the increase of their age; 3. Children of LD slightly raise their average F0 and keep F0 variation during their growth; their F0 variations are also significantly higher than TD children after age of 30 months; 4. When speaking to child, adult-females significantly raise their F0 and F0 variation which is the effect of motherse, this is even stronger for those of ASD group; 5. It seems that adult-females of ASD group have higher F0 and F0 variation no matter speaking to child or not, they are affected by ASD children significantly.

Contact: DongxinXu@LENAFoundation.org 303-441-9012