Augmentative Communication Device

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Client: Lawrence Kaplan, MD
Advisor: Dr. Amit J. Nimunkar, PhD

Abstract

Dr. Lawrence Kaplan, at the Child Development Clinic at the Waisman Center, has noticed that there exists a lack of communication devices for people who have lost the ability to produce sound. Current products are slow, impersonal and expensive. We have developed a device that allows the user to reduce the time between cognition and speech, use unlimited vocabulary and add inflection to their statements.

Motivation

This device is meant to help people with the inability to produce the sounds necessary for speech. It seeks to:

- Reduce the time between cognition and speech
- Allow for more expressive language
- Eliminate the limitations of current devices
    - Slow
    - Impersonal
    - Restricted in use of language

It seeks to do this by replacing the function of the vocal chords and larynx. This device helps people with conditions such as cerebral palsy, laryngectomies, paralyzed diaphragm and other physical difficulties with speech.

Client Requirements

- Phonetics-based device
- Reduce the delay between cognition and speech
- Create the ability to engage in normal, everyday conversation
- Affordable (Preferably well under $1500)
- Portable
- Adaptable to various types of speaking difficulties

Physiological Background

This device seeks to replace some of the non-functional aspects of physiology in someone with the inability to speak.

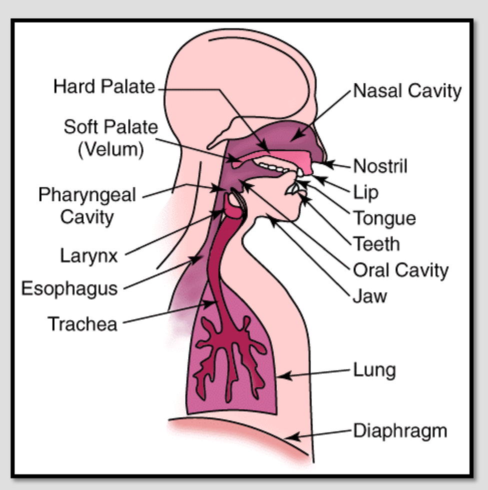

Figure 1: A diagram of the anatomical structures used in the production of speech

- The compression driver replaces the diaphragm and lungs by producing the required current of air
- The compression driver also replaces the vocal cords by generating the sound
- The sound source mimics the larynx by allowing the user to modulate pitch and tone
- This device still requires the functionality of the lips, tongue and facial muscles.

Final Design

- We have taken the design from last semester and created our own circuit that accepts customizable input
- Signal provided by an iPod
    - Recorded vocal sounds
- Signal is amplified before passing through the compression driver
- The compression driver generates mechanical sound from the signal and the signal is propagated to the mouth through a tube
- The mouth shapes the sound into language

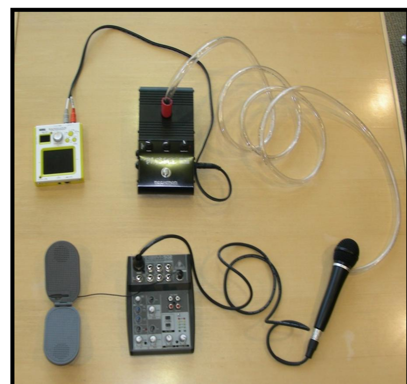

Figure 2: Our project first semester consisted of a Kaossilator, Talkbox, microphone, mixer and speaker

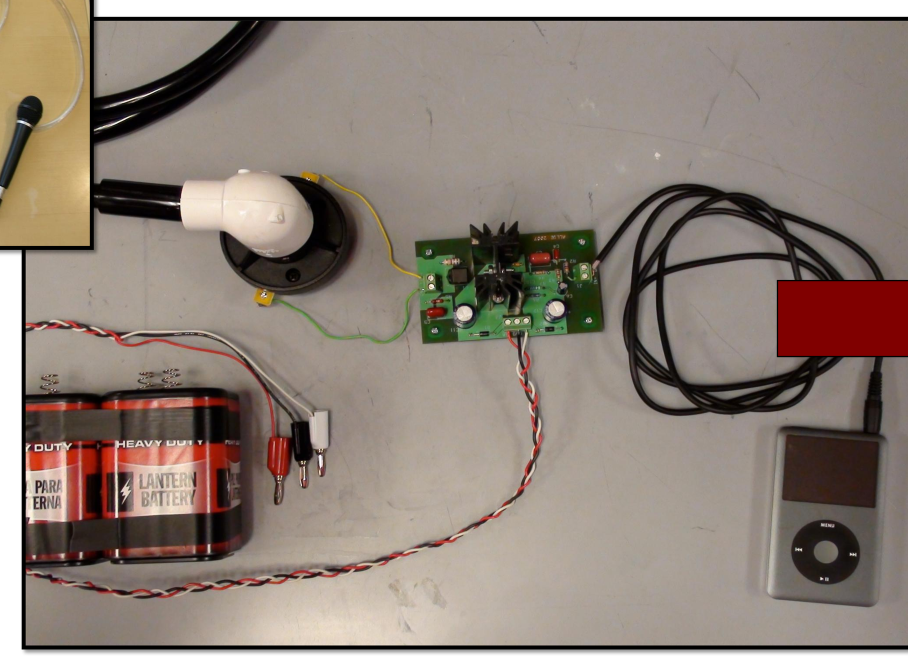

Figure 3: Last semester we created our own circuit using a compression driver amplifier, iPod and large batteries.

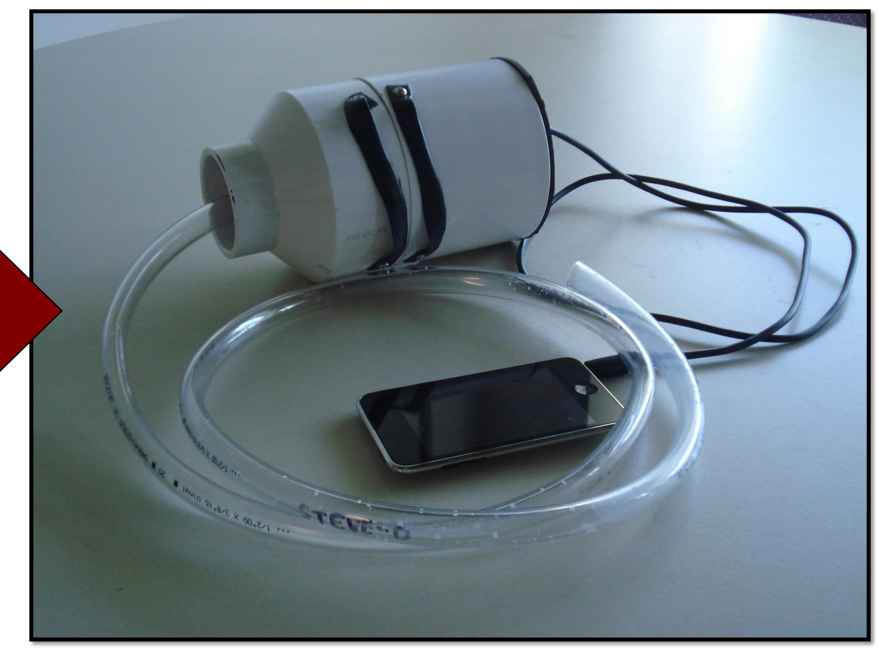

Figure 4: This semester we have made the circuit even smaller by reducing the size of the amplifier and the batteries.

Testing– Similarity to Natural Speech

FFT of "O"

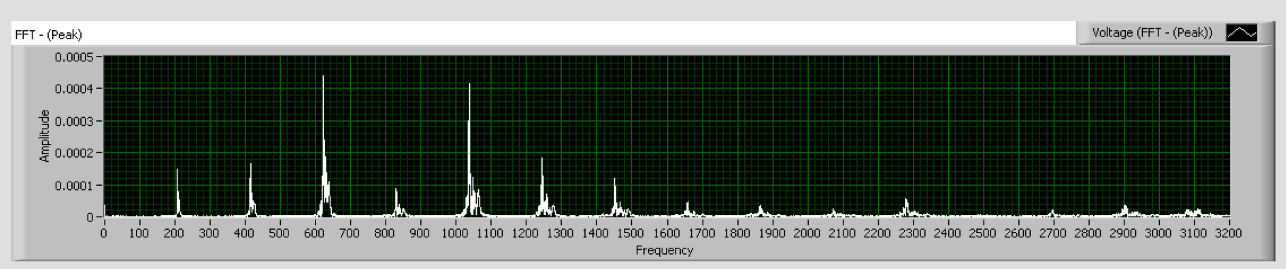

Figure 5: An FFT of the "O" sound of a natural voice.

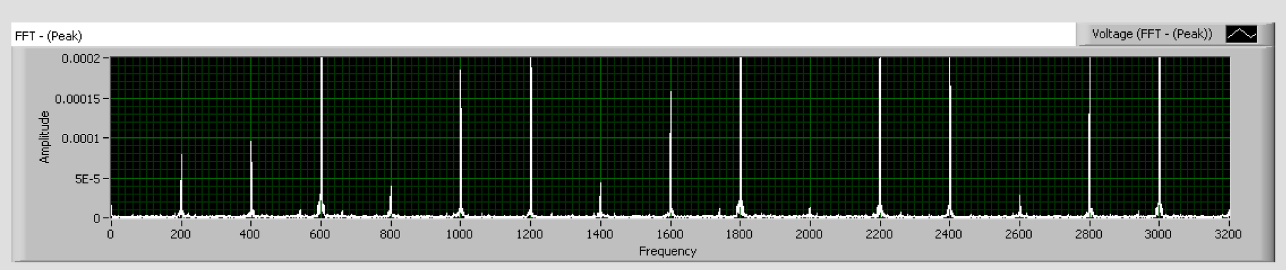

Figure 6: An FFT of the "O" sound using the device with a pure frequency input of 600 Hz. This graph shows that the user was able to modulate the pure frequency to get the formant frequencies matching those of the natural sound.

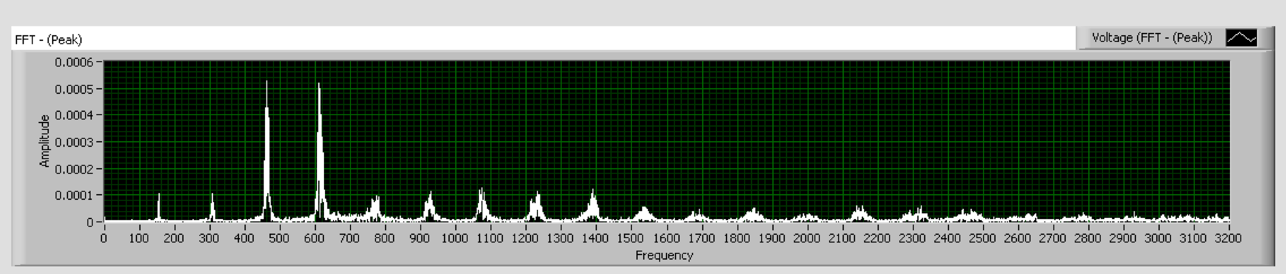

Figure 7: An FFT of the "O" sound using the device with prerecorded human voice. This graph shows that the desired formant frequencies were achieved without the high frequency harmonics seen when using the pure frequency input.

Method

In order to characterize the quality of speech produced by the device, we used fast Fourier transforms. We compared the FFT of a user's natural voice to the FFTs of the device with a pure frequency input and the device with a prerecorded human sound input.

Results

We found that with the device the user was able to modulate the incoming sound and produce the formant frequencies seen in the FFT of the natural voice. This was demonstrated with the pure frequency input. Results with the prerecorded human sound source also matched the formant frequencies and didn't have the problem of higher frequency harmonics of the pure frequency input. These results can be seen in figures 5-7.

Testing– Tube Length

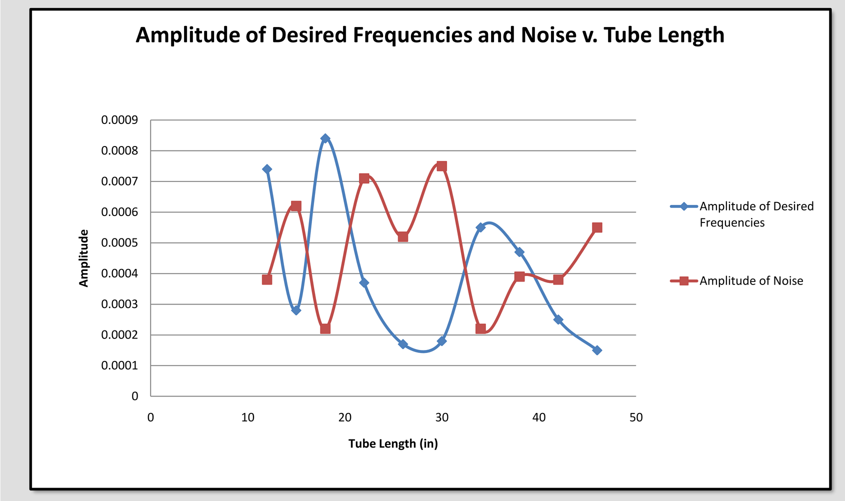

Figure 8: A plot of the amplitude of desired frequencies and the amplitude of noise v. tube length. This data shows that while some tube lengths appear to be better than others, there is no real trend to the data. This suggests that while tubing length may have a small impact, the quality of sounds depends more on the user's ability to modulate it.

In order to characterize an ideal tubing length we performed FFTs of the user saying "O" and compared the amplitude of the desired frequencies and the amplitude of the noise. We found no real trend to the data.

Future Work

- Continue development of a more commercial sound source (iPhone/Android application)
- Create a more commercial packaging
- Continue testing and refining sound input and amplification
- Develop method for sterilization (UV)
- Finalize patent process
- Present to interested corporations

Budget

Last semester:
- Compression Drivers $30
- Various Supplies $25
- iPod $250

This semester:
- Amplifier $49
- Packaging $15
- Various Supplies $10

Grand Total for the current design: $379

Special Thanks

- Our Advisor: Dr. Amit J. Nimunkar, PhD
- Our Client: Dr. Lawrence Kaplan, MD
- Professor Mark Allie
- Peter Klomberg

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