Project Design Specifications
Tactile Auditory Sensory Substitution
Jimmy Fong, Jack Page, Ryan Thome, Becky Jones, Matthew Valaskey

Function:

High frequency hearing loss is the most common form of hearing loss experienced. It is caused by damaged nerve ends on the hairs in the cochlea. People with high frequency hearing loss cannot hear high frequency sounds such as 's', 'f', 'sh', 'ch', 't', and 'p' sounds. Since these sounds are some of the most commonly used in the English language, high frequency hearing loss immensely inhibits communication.

Individuals with high frequency hearing loss tend to rely on hearing aids, which amplify sounds. However, the hearing loss cannot be fixed with amplification of these high frequency consonants because the person simply cannot hear in that frequency range, the volume does not make a difference. Instead of amplification, these missing consonants can be communicated by sensory substitution. In other words, a sense other than hearing can be used to send the auditory information to the brain. The goal is to design and develop an auditory substitution device that through the use of vibro-tactile stimulation can substitute for regional frequency hearing loss. Individual vibrators will represent certain frequency ranges, and when the user feels the specific vibration attributed to certain frequency range, the user will be able to identify the sound.

After using the device for an extended period of time, the user will no longer have to concentrate on the vibrations but will be able to "hear" the high frequency sounds. Due to the plasticity of the brain, the brain will interpret the vibrations as sounds and fill in the gaps for the user, and communication will be restored.

Client Requirements:

- The device will substitute for high frequency hearing loss to the extent of helping the user in everyday communication.
- The device will use vibro-tactile stimulation.
- The device should be self contained, portable, and discrete.
- Complete a testable prototype for analysis of frequency range and wear-ability.
- Test the prototype, obtain results, and determine efficacy.

Design Requirements:

1. Physical and operational characteristics

a. Performance requirements

- It will increase the user's quality of communication by allowing the user to recognize high frequency consonants and incorporate them into word recognition through vibro-tactile stimulation.
- This device should use real time analog filtering to recognize and separate certain high frequency sounds and communicate them to the vibro-tactile stimulator.

b. Safety

- A current of more than 5 mA should not pass through the device and into the user.
- The device should not heat to over 43° C (110° F) while in use.
- Testing protocol should comply with all IRB regulations.

c. Accuracy and Reliability

- Be able to detect sound at normal speaking level of 60 dB while rejecting environmental noise.
- Be able to process and substitute for the consonants T, F, S, Th, Sh, and P when coming from a variety of different vocal tones enough to improve scores on standard speech recognition evaluation tests, Word Intelligibility by Picture Identification (WIPI), sentence level Bamford-Kewal-Bench test (BKB), and PLOTT test for vowel and consonant discrimination.
- Human Hearing Frequency Range: 20 – 20,000 Hz
- Speech Frequency Range: 125 – 8,000 Hz
- High Frequency Hearing Loss: above 1,000 Hz

Sound	Frequency (Hertz)
T	3500
F	4000
S	4000
Th	4000
Sh	2000
P	1500

d. Life in Service

- The transducers should last at least 3 years.
- The sound processing unit, along with its microphone, should last 10 years.
- Adhesive should last at least through an entire day.
- On a single battery charge the device should last approximately 5 days, similar to that of a common hearing aid.
- Common hearing aid batteries have an output voltage of 1.4 V and have power ratings between 140 and 640 mAh. With daily use of the device being about 14 hours the device should draw from 2 - 10 mA of current from the battery.

e. Operating Environment

- The device will be located behind the ear.
- Elements such as wind, rain, sun and sweat should not cause the device to vibrate for non-spoken noises, output dangerous levels of current or distort outgoing signals.
- Eventually test the prototype on human subjects in a lab setting.

f. Ergonomics

- The device should not move during normal physical activity.
- Transducer unit should be hidden by the ear.

- Device should be comfortable to the user.
- The controls of the processing unit should be small enough to keep them discrete yet still be able to be manipulated.
- Attach vibro-tactile device with adhesive that will not cause irritation.
- The location of the transducer should be easily repeatable.

g. Size

- The transducer unit should be no more than 5 cm in length, 1.75 cm wide, and 1.25 cm thick.
- The processing unit should be no more than 10 cm in length, 5 cm wide, and 2 cm thick.

h. Weight

- The weight of the processing unit should be no more than 8 oz.

i. Materials

- Adhesive which holds the transducer unit in place should not irritate skin, leave large amounts of residue, or be painful to remove.
- Soft, durable plastic such as vinyl.
- Housing unit made of material to absorb vibrations.

j. Aesthetics, Appearance, and Finish

- Unit should be flesh-colored and not overtly noticeable to others.
- Adhesive attachment used for transducer unit should not leave large amounts of residue and should not be painful to remove.

2. Production Characteristics

a. *Quantity*: The device should be able to be produced in mass quantities.

b. *Target Product Cost*: The device should cost between $300 and $500, which is approximately 5-10% of the total cost of a hearing aid.

3. Miscellaneous

a. Standards and Specifications: FDA approval of a class II device. Must follow regulation code 21 CFR 812 and 21 CFR 50 for testing.

b. Customer: Adjustable frequency ranges depending on what the user needs most

c. Patient-related concerns: Device should not cause discomfort and should not be overly noticeable.

d. Competition:

- Tickle Talker
- Tacticon 1600
- Tactaid 7 – http://www.tactaid.com/tactaid71.html