MolarWave. process & design

Chandan Hebbale
Georgia Institute of Technology – Master of Industrial Design
Herb Velasquez, David Cowan
Problem
Initial Problem

How can a research based design solution help senior citizens with arthritis and hearing loss maintain independent living, within a smart home setting?
Discover
Discover

Design Drivers:

1. Academic Research - Conducted research on the physical, social, and medical interactions between arthritis & hearing Loss

2. Senior Citizens (HomeLab) - Identified those with both arthritis and hearing loss from the Home Lab data, and set up relevant interview questions.

3. Smart Home (Aware Home) - Gained an understanding of the layout and capabilities of the Aware Home
Discovery Analysis
Osteoarthritis & Hearing Loss

The bones in the middle ear, shown in Figure 1, pivot around the incudomalleolar and incudostapedial joints to translate the pressure waves of sound coming in, into hydraulic pressure waves within the cochlear fluid.

Osteoarthritis can attack the cartilage at these joints, and middle ear inefficiency will lead to hearing loss that cannot be fixed by normal air conduction hearing aids (Rawool 2006).
Untreated Hearing Loss

Hearing loss, which is defined as recognizing only those sounds louder than 25 decibels, affects as many as 27 million Americans over age 50 (Lin 2013).

Apart from surgery, hearing aids are the primary treatment for hearing loss, but audiologists report that only 15 percent of those who need a hearing aid get one (Lin 2013).

This number is a result of multiple factors including 

vanity, denial, and fear of social stigma (Trychin 2001).
Hearing Aid Market

There is a large market for hearing aids, and the market is moving towards more invisible, and feature driven products.

However little attention has been paid towards those with Arthritis. Most of the innovative devices coming to the market are far too small for those with arthritis to:

1. Put in and take out of ear
2. Charge device or Replace battery
3. Clean device
Observation

Using a **pencil** to poke out the battery

**Peeling** the back cover off the battery

**Dropping** the battery when placing into the hearing aid
Aware Home

Potential Smart Home Commands

- Eliminate small area interactions for arthritic consideration

Can control lights – Light Switch
Lock and unlock doors – Door Knob
Control thermostat – Thermostat Pin
Control window shutters – Shutter Rod
Controlling TV – Remote Buttons
Define
Middle ear hearing loss can only be treated by bone conduction, and there is not an efficient and scalable alternative to the Bone Anchored Hearing Aid (BAHA) procedure.

Research also indicates the need for a cost effective and invisible hearing aid, of which BAHA is neither.
Replacing BAHA

The elderly with hearing loss and arthritis need a hearing aid that is able to operate and be adjusted with very little to no interaction required.

In the realm of bone conduction hearing aids, a device like this does not exist outside of the BAHA.
Smart Home Control

The Aware Home has the capability of offering smart home functions that would be useful to the user, but controlling those functions lacks a single point of command, especially for those with arthritic in capabilities.
Problem Definition
In the scope of helping the elderly manage arthritis and hearing loss, the innovation space to the design of a bone conduction hearing aid that meets the following criteria:

1. A hearing aid that is effective at transferring sound via bone conduction, but is also fitted in a non-invasive manner.
2. A hearing aid that is scalable, and is designed for mass manufacturing in order to lower cost.
3. A hearing aid that cannot be visually recognized when in use.
4. A hearing aid that is able to operate and be adjusted with very little to no interaction required.
5. A hearing aid that is able to access smart home capabilities via a single point of command that requires very little to no interaction.
Develop
By using the upper jaw as the bone conduction medium rather the skull, dental drive bone conduction allows for a device to transfer sound to the cochlea in an effective manner while also opening the possibility of non-invasive fitting.
MEMS Microphones

By utilizing miniature MEMS microphones, different forms and locations for the mic pickup can be explored.

MEMS microphones allows the design to transition to one that is not visually recognizable.
Wireless Recharging

Every hearing aid on the market requires a specific point of interaction were the batteries have to be replaced or recharged.

By utilizing a wireless changing scheme, it allows the device to have a smaller battery and be able to recharge without having to remove the device.

This feature allows for the patient to be able to use the device with no interaction with battery replacement.

However, this means that both the hearing aid and microphone will need to have an internal battery and charging coil.
Voice Command + Wi-Fi

By incorporating voice command as the single point of command, the design is able to offer the patient a way to adjust the hearing aid and have access to smart home capabilities in a manner that requires no interaction except for speech.

However incorporating both of these aspects into the design will require a certain amount of space allocation.
Concept 1 - Sticker

• Can easily keep on in the shower and wear to bed.
• Inexpensive and can be replaced easily if damaged or lost.
• Good place for consistent sound capture from all sides.
• However it may not be able to incorporate the amount of space allocation needed.
Concept 2 - Tattoo

- Can easily keep on in the shower and wear to bed
- Inexpensive and can be replaced easily if damaged or lost
- Good place for consistent sound capture from all sides
- Customizable, and allows the user to make the device part of who they are
- However it may not be able to incorporate the amount of space allocation needed.
Concept 3 - Glasses

- Good place for consistent sound capture from all sides
- Customizable, and allows the user to make the device part of who they are
- Has the space allocation required for the design
- Gives the microphone a form factor that allows to be not visually recognizable when used.
Final Concept
Introducing. MolarWave.
Custom Comfort

- A dental drive hearing aid that is placed in the area of the mouth that is almost invisible to daily function.
- It is cost effective, as it is manufacturable in 3 standard sizes.
- The shape can be remolded by placing in hot water, and can then be fitted comfortably to any patient type by a dentist.

Bone Conduction Resonator

- Aluminum-Ion Battery
- Solenoid Micro-Coil
- RF Communication
MolarWave Technology

Solenoid Micro-Coil
- 500 picometers wide
- Best power transfer of all Micro-Coil geometries

Aluminum-Ion Battery
- 7,500 recharge cycles
- Flexible design allows the battery to run along the length of the dental design, and be able to flex during remolding

Bone Conduction Resonator
- 5 x 5 x 2 mm
- Miniature device that allows the hearing aid to stay lightweight and out of the way
In combination with the dental design, the MolarWave system will be unrecognizable in plain sight.

Components inside glasses:

- Microphone on either end
- Internal battery
- Solenoid Micro-Coil
- RF Communication
- Wi-Fi Communication
The packaging of the MolarWave is designed specifically for a dentist to immediately understand **where and how to fit the device** to the patient.

- Molar numbers are indicated on either end.
- UV curing sites are show in blue.
- And a molding rod is given so that the device can be removed cleanly from hot water.
Charging in Rest

- The MolarWave comes paired with a wireless charging mat that is placed under the pillow.
- The power transfer is safe for humans, and while you are sleeping, the MolarWave is charging.
- The device has an internal resonance coil, and an AC out cable.
Charging in Rest

- The glasses case for the microphone also acts as the wireless charging base.
- It has a magnetic top so that the user will be able to place the glasses on the case and be assured that it will not roll off.
- The device has an microUSB out and an internal resonance coil.
Impact
Storyboard - 1

- When you are ready to go to bed, set a wake up alarm via the glasses using voice command
- Once the alarm has been set, place the glasses on the case to be charged as you sleep
- In addition, the glasses will still be transmitting sound as you sleep, so if there is an emergency in the night, you will be able to hear it.
• With the bed mat under your pillow, the MolarWave will be recharging wirelessly while you sleep
• Even if the device coil is not directly in line with the bed charger, the MolarWave will still charge
• Wake up to an alarm only you can hear
• With the MolarWave system fully recharged, and ready for a new day
• For those with middle ear hearing loss, the only effective current solution is the highly invasive BAHA hearing aid that sits on the skull.

• MolarWave offers cost effective, non-surgical solution that is truly hidden in plain sight.