Light Sleeper

Project Four: *Not a Pun, It's Real Life* | Prototype Design Brief

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First Prototype Overview (Comprehensive)

When our client takes her cochlear implant receivers off at night, she is unable to hear audible emergency alarms or her smartphone alarm. Thus, we decided to create a device that works to wake her up when her receivers are taken off. Our initial idea was to make a sleep mask for our client with LEDs of different colours that turn on in response to her smartphone alarm and other audible emergency alarms (e.g. smoke alarm) in her house. To respond to her smartphone alarm, the device would connect to an app on the client's phone and wait for a Bluetooth signal before turning on LEDs to wake the user. To detect an emergency alarm, the device would use AI technology to analyze microphone signals for high pitched alarms. In our device, there would be LEDs of different colours to differentiate between a user alarm and an emergency alarm. The device would also feature electronic screens that can display additional information such as the time or type of alarm detected. Our circuitry would include a Raspberry Pi Zero that uses wireless communication, a battery pack, some LEDs, and some jumper wires. The purpose of this prototype was to represent our idea tangibly with very basic parts.

Low-Fidelity Component (see Figures 1-3)	**Representation:**
Cardboard from empty toilet paper rolls	Eye padding
Yellow pom poms	LEDs that would light up to wake the client
Purple pieces of paper in the eye regions	Electronic screen
Red pipe cleaners rolled into spirals, placed on the nose	Microphones would be placed on the nose as it is less likely to be covered during sleep

Figure 1: Demonstration of proposed prototype #1 worn on a user

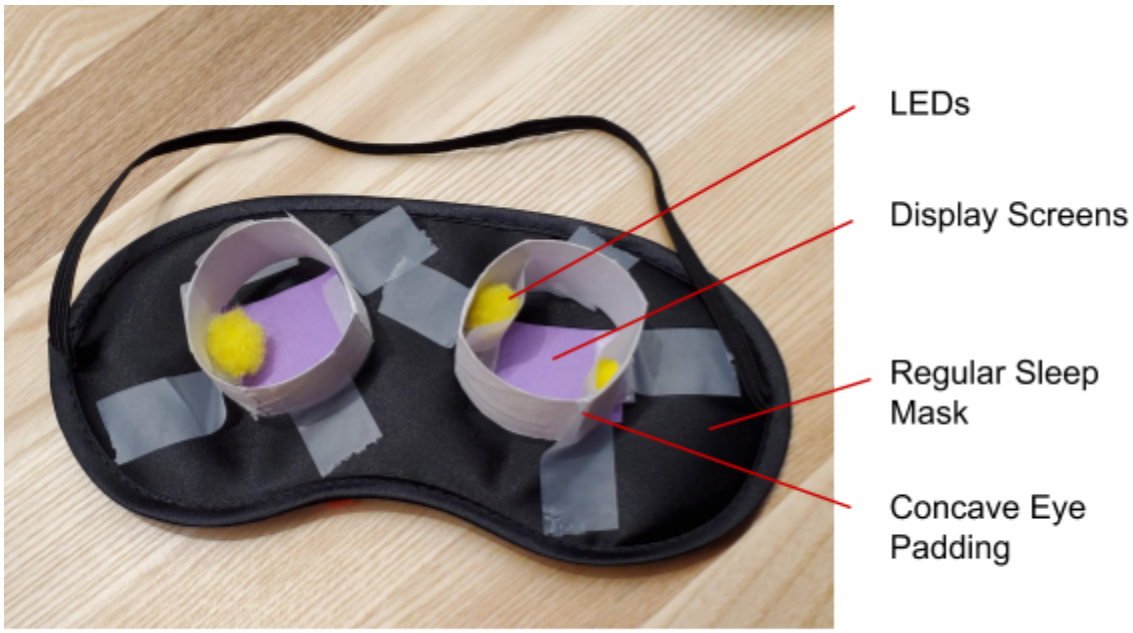

Figure 2: Prototype #1 of Sleep Mask (Inside view)

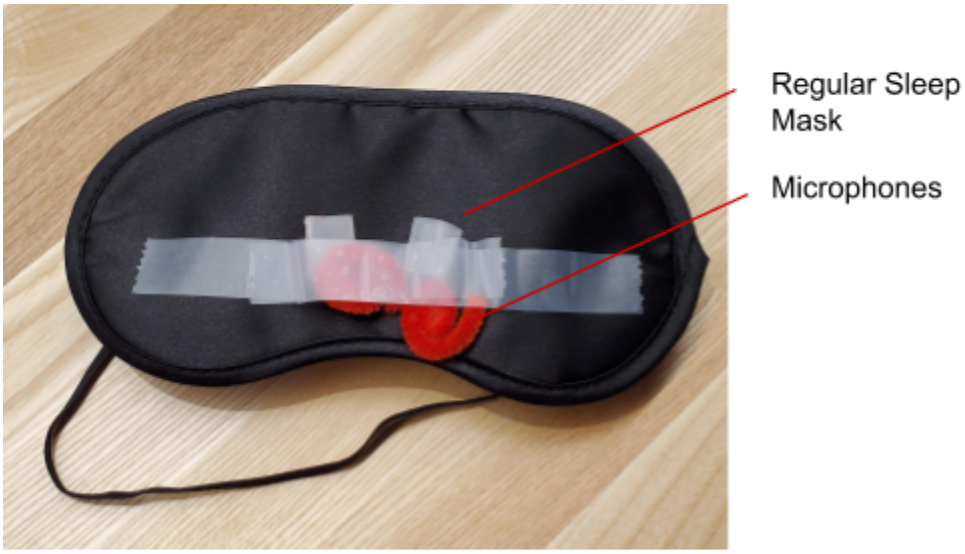

Figure 3: Prototype #1 of Sleep Mask (Outside view)

Prototype External Feedback

When discussing with the mentors, they recommended minor revisions to our device. We were told AI is hard to train and is not always accurate, which is dangerous if our device cannot decipher alarms. There would also be a problem if the client buys new alarms; the neural network of the AI must be retrained. It was recommended to instead find a way to wirelessly connect the device to the alarms for a more accurate response. A suggested method was to have a smartphone app act as an intermediary connection. The app could do most of the processing and could connect with on-the-market smart alarms that send signals to the phone when they turn on. The phone could process these signals and output them via wireless connection to the mask, while the mask's only task would be to receive the wireless signals and correspond them to specific LEDs in a circuit.

Prototype Internal Feedback

Our Internal Feedback can be grouped into three categories. Firstly, regarding the overall design, we realized the placement of LEDs without any additional material to protect the eyes could be harmful or uncomfortable. Therefore, we noted that we had to soften the light coming from the LEDs. Secondly, regarding our proposed phone app, we needed to choose one wireless connection method to connect to the device as there are many options available such as

Bluetooth or Wifi. Finally, in the creation of preliminary circuitry for the mask, we learned how different LEDs have different brightnesses, how different LEDs require different voltages to achieve the same brightness, and how brightness is affected by placing LEDs in series or parallel. To avoid these complications, we considered using LED light strips as they eliminate the need to solder LEDs together and the lighting is more consistent throughout the strip for a specific voltage.

Proposed Prototype Revisions

Original Plan	Implemented Revision / Plan for Revision + Justification
Train a neural network to recognize alarm sounds through a microphone.	Removed microphones on the device and planned to connect the smartphone to smart alarms, using the smartphone app to send/receive wireless signals to the device to turn the LEDs on or off.
Have screens on the inside of the device to visually provide more specific information on the reason the device is lighting up.	Removed the screens because we wanted our device to be minimalistic, and we realized that the screen would increase the complexity of the coding and circuitry required, adding to the bulkiness of the device without a sufficient reason.
Find a wireless connection method to connect the phone & the mask.	Chose Bluetooth to connect the device & phone since both the RPi and smartphone support it and Bluetooth offers a direct connection between devices through pairing.
Solder individual LEDs together into a circuit and insert the LEDs into the mask.	Use RGB LED light strips which provide multiple colours and a consistent lighting with less soldering needed.
Soften light from LEDs.	Cover RGB LED strips with translucent tape to act as a diffuser.

Final Prototype Specifications

Device Components, Materials, and Manufacturing

See **Figure 6** for a sketch of the final device, including placement of all components.

- Padded sleep mask by MZOO seen in **Figure 4** is used as the base
    - The MZOO mask includes memory foam for the concave eye components. No other specific materials for this mask were found, but for reference some common mask materials are bamboo rayon, cool cotton, memory foam, and silk [1]
- RGB LED strips seen in **Figure 4** turn bright yellow for a regular alarm or red for a dangerous alarm
    - The strips are inserted within the eye rings
- Raspberry Pi, jumper wires, and a rechargeable Raspberry Pi battery provided by PiSugar
    - Inserted underneath front layer of mask
    - If the battery loses charge, plugging the device into an external power source will reboot the Pi and the program which communicates with the smartphone app
- Eye-piece can be removed in order to be cleaned
    - Attached to rest of device with snap fasteners
- Translucent tape placed over the LED strips in the eye holes to act as a light diffuser

Figure 4: Components for mask: MZOO sleep mask (left) and sample RGB LED light strip (right).

Image Sources:
https://www.amazon.ca/Contoured-Sleeping-Blindfold-Concave-Meditation/dp/B07KC5DWCC
https://www.bc-robotics.com/wp-content/uploads/2016/11/purple.jpg

Phone App Would:

Have <u>three</u> main functions (see **Figure 5**):

1. Ideally be able to connect to smart home devices and transmit a bluetooth signal to the Raspberry Pi when one of the smart alarms are triggered to light up the mask
    - To represent this functionality, we have a **'test emergency alarm' button** on the app that represents a smart alarm sending signals to the phone. This button sends a bluetooth signal to the device to turn on red lights
2. Has a **'set alarm' button** for the client to set an alarm to wake up. The device turns on yellow lights when that time comes.
3. Has an **'off' button** to turn off the lights on the device
    - Once activated, the lights will remain on by default unless turned off by the client

Figure 5: Phone app prototype wireframes
('connect to alarms' screen would likely be just for show due to time constraints)

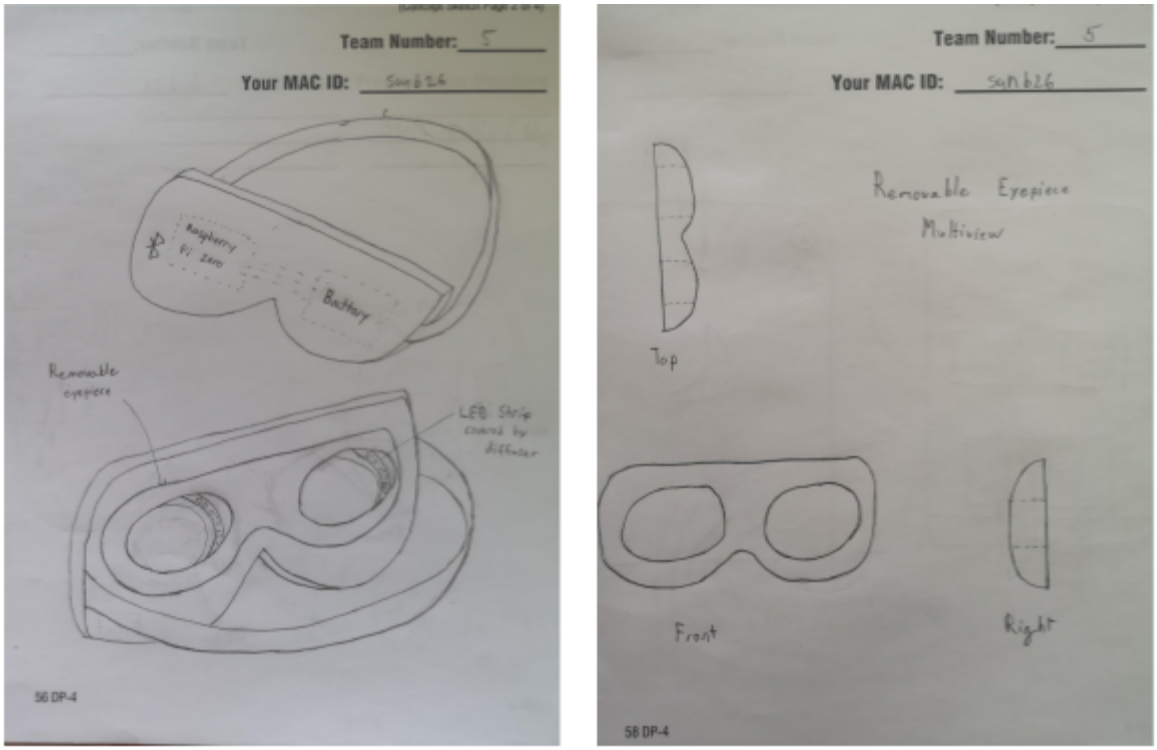

Figure 6: Sketches of proposed design for final mask (left) and removable eyepiece component multiview (right).

Final Prototype Design Verification

The design verification would have a software-centered component and a client-centered component.

The software-centered component would be tested after pairing the device to the smartphone through Bluetooth. To test the wake-up alarm function of the mask, we would set an alarm through our app and observe if the yellow lights on the device turn on within 5 seconds of the alarm triggering and remain on. To test the emergency alarm feature, we would push the 'test emergency alarm' button on the app and observe if the correct lights are turned on within 5 seconds and remain on. To test the off button on the phone app, we will press it at some point after the lights have been triggered by one of the previous two tests and the device's lights should turn off within 5 seconds.

Next, there would be testing for the client-centered component. To verify the comfort of the device, we would have our client wear the device after taking off her cochlear receivers and

adjust it to her liking. We would then have her apply slight pressure on different parts of the device to try to simulate her lying down in bed, and rate the comfort out of 10. The comfort test can be done with the client's cochlear receivers disconnected, if they consent, as the device is designed for when she takes them off. The following tests can be done with the receivers connected. To test the effectiveness of the device, we will have our client wear the device and close her eyes. We would then randomly turn the lights on without telling our client and they must tell us if they can notice when the lights are on. To ensure the lights are not hurting her eyes, we would have her wear the device and open her eyes for 15 seconds while the lights are on. If she feels any discomfort in this step, she can close her eyes and remove the mask, meaning the test did not pass. Then we would ask her to take the device off, and after a minute we would ask if her vision is the same as before. Finally, we would test our client's ability to easily use the device and the app by turning the device's lights off and then performing the following steps herself:

1. Pair phone to device (through Bluetooth)
2. Set alarm through app for 2 minutes from the current time
3. Put on the device and remove when you notice the lights turn on
4. Turn device lights off using phone app
5. Unpair phone from device (through Bluetooth)

References

[1] "Best Sleep Masks - Reviews and Buying Guide (2020)," *Tuck Sleep*. https://www.tuck.com/sleep-mask-reviews/ (accessed Mar. 23, 2020).