CSE 440 - Autumn 2014
2h: Final Report

Soundscape

Team

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Problem and Solution

Leaves blowing, the sounds of traffic, our radios, the construction workers down the street—they all contribute to our soundscape, the combination of sounds that arise from our acoustic environment. When this environment reaches excessive levels that affect the balance of our health, we call it noise pollution. Recently, studies have shown that noise pollution can cause stress related illnesses, high blood pressure, hearing loss, sleep disruption, a loss of productivity, and even an increased risk of heart attacks. Most people know when things “feel” too loud, but many people are unaware that consistent exposure to seemingly innocuous sounds can cause some of the adverse health effects listed above.

We propose a smartphone application that will constantly monitor, track, and display sound exposure using the built-in microphone on the device. By allowing users to see objective data on the sounds in their life they can then make conscious decisions regarding their personal soundscape. This app will also seek to raise awareness of the dangers of noise pollution, crowdsource noise data into an environmental “sound map”, and emphasize the health and psychological benefits of quieter spaces.

Contextual Inquiry Participants

During our brainstorm, we found that few people who work in moderately loud environments are unaware of the risks of hearing loss from consistent exposure. We wanted to talk to people who are exposed to these “almost loud” environments on a regular basis both socially and professionally, and whether or not wearing hearing protection is an option for them. With this in mind, we selected and interviewed Levi, a pasta cook in the restaurant industry; Matt, a professional drummer; and Nate, a student at Dartmouth College and fraternity member. All names have been changed. These inquiries were done using an interview model, as a master/apprentice model was either impractical or unnecessary for these individuals.

Levi, the restaurant worker, is currently the pasta cook at Serafina, a fine dining restaurant in the Eastlake neighborhood. He has been in the industry for seven years and worked for six different establishments including a catering company, open-kitchen fine dining, and a closed-kitchen diner. In his experience, the loudest kitchens are highly dependent on the restaurant’s clientele and ambiance (fine dining is the quietest), the style of the kitchen (closed kitchens are much louder), and the number of customers currently in the restaurant (loudest during the rush). The unique aspect of this inquiry was the fact that none of Levi’s coworkers (in his experience) have ever talked about hearing loss. When asked about using hearing protection while working, Levi was quick to say that it was not feasible: “You have to have all of your senses in the kitchen.” Levi was also interested in a way to track his noise exposure, only if he was not required to purchase additional hardware.

Matt, the professional drummer, started playing drums when he was a toddler, joined a band in middle school, went to college for music performance, and is currently making a living as a professional drummer in Seattle. He plays an average of 4-5 nights a week, as well as numerous practices and rehearsals during the day. As of now, he has not had any symptoms of hearing loss after shows, and says that this is because he “can tell when things are too loud” and take steps to limit it. When asked to describe the sensation of “too loud”, he could not. When this happens, he says he puts in earplugs or other hearing protection. He says this is not ideal, though. His interview was unique in that he knows numerous people in his industry that have hearing loss from their playing—mostly gospel drummers. He expressed a strong interest in a noise tracking application, and hopes it would include a real-time warning system for loud environments as well as a daily timeline of noise exposure.

Nate, a current student at Dartmouth College, reports being exposed to high levels of noise in social spaces at least three times per week. While he is aware of the potential risks that this type of exposure poses, he has not considered the long time implications, and rarely considers changing his behavior. Nate’s noise exposure is unique compared to the other people we spoke with in that his exposure is due solely to his personal choices, not required by a job. Because of this, the user group that Nate represents is likely one that our group would like to target, as they have full control over their noise exposure. Additionally, targeting a young user group such as students will bring more significant meaning to any behavioral changes due to our solution. Nate said that he would be interested in something that could track his noise exposure, but would prefer something that would be convenient and not get in the way. Furthermore, Nate is more interested in tracking the noise level in his current environment, and would like to know the health implications of that level of exposure. However, he is less interested in a long-term tracking solution because he feels that he would not want to make many major adjustments to his behavior.

Contextual Inquiry Results

While we interviewed three very different people for our inquiries, there are several commonalities and themes among them. First, all of our inquiry participants were aware of the noise exposure in their activities. Though at first glance this does not seem particularly profound, each of our participants claimed to know when things “seem too loud”. Thus, they are all aware of it, but this awareness is subjective and completely dependent on their environment and current state. Second, they all expressed a strong aversion to wearing hearing protection during their respective activities. For example, the restaurant worker needs to stay in constant communication with his coworkers and remain safe in the kitchen. The drummer (though he does use it occasionally) is strongly against it, and the fraternity member is in a social environment that necessitates interaction. Third, all of them were convinced that hearing loss is not something that will happen to them in the near future (likely true) and seem unwilling to make any big changes to their lifestyles. In regards to that, all of our interviewees are able to sense things getting too loud, and we have observed that each of them has some way of evading a loud environment to make themselves feel better. The cook takes breaks as often as he is able, usually on his trip to the freezer where is a lot quieter. The drummer does not play very loud during practice and uses ear protection. The fraternity member would step away from the loudest part of the social scene when he feels it is too loud. Lastly, all of them expressed a strong interest in a noise-tracking mobile application, especially if it did not require any extra hardware.

Fortunately, these major themes we have identified lend themselves directly to obvious design tasks. Because each of our participants was subjectively monitoring their daily noise, including an accurate decibel meter in our design is crucial. We need to ensure that our users are provided with objective measurements of their daily noise exposure. Without this consistency, accurate feedback is impossible. A problem posed by our participants was that wearing hearing protection was impractical or even impossible during their activities. This would indicate that an important design feature would be to monitor for excessive noise limits. While 95 dB is in a dangerous range, it takes hours for any hearing damage to occur. Our design needs to include a monitoring device for when environment spikes *above* this limit. When this happens, our users should be notified of their increase risk and exposure so they can take appropriate steps before it causes damage.

> *(Note: after further review and discussion with our inquiry participants, we have established that an alert system for excessively loud environments is not practical in our design. The vast majority of the time users are exposed to loud soundscapes it is an intentional decision. We do not want to repeatedly alert them in an environment they have no desire to change)*

Additionally, none of our participants were concerned about hearing loss in the near future. When something is 30 years away (or more), it is much harder to consider it in your day-to-day choices. Our app design needs to include a strong focus on noise education for these particular users. If we can clearly indicate exactly what kind of damage is being inflicted, we might be to make the abstract symptoms of the future much more tangible. Also, all of our inquiry participants were interested in a noise tracking application, provided it was just an application. While an external peripheral could provide higher accuracy and improved battery life for our app, all of our features should be accessible with just a smartphone or other mobile device since it is already a common technology that most people already posses. Any additional peripherals need to be optional, and only useful in cases where extreme accuracy is required or static environmental tracking is desired. Finally, we wanted to address the issue of effectively nudging users to be cognizant of their noise exposure without forcing them to leave favorable situations or events. We decided to tackle this issue by promoting the times of silence, meditation, or “zen” to show the health benefits of non-noisy environments. This way, we want to give users incentive to increase the amount of times during that day that they are in quiet environments without necessarily forcing users against their will.

Task Analysis Questions

1. **Who is going to use the design?**

   People who are concerned about their noise exposure and personal soundscape will be the majority of users that use our design. These will primarily include people who work in loud environments, people that live in metropolitan areas and/or near sources of noise, and people looking to make behavioral changes to gain the health benefits of a quieter life. Additionally, anyone who is interested in personal informatics and monitoring sound levels with respect to time can be benefited with this design.

2. **What tasks do they now perform?**

   The majority of people judge “loudness” using subjective methods of perception and very few people (except those in OSHA-monitored workplaces) have objective knowledge about their sound exposure. If something is “too loud”, they try and take steps to minimize their exposure (if possible). However, if something is “loud” but not unbearable, many people do not address this problem right away. It is often inconvenient to change the current activity, and many people remain in the loud environment.

3. What tasks are desired?

The six main tasks of our design are as follows:

Task 1: *Objectively measure and record environment dB levels at frequent regular intervals throughout the day*. Ideally, this app will provide equivalent functionality to current sound meter systems.

Task 2: *View a visual recap of past noise exposure*. Users should be able to see both noisy and zen data and make conclusions at a glance.

Task 3*: Analyze sound data and communicate the long-term effects of current exposures (both noise and "zen")*. Users will have the option of viewing a detailed analysis page in which data is presented with a more educational focus regarding their personal noise exposure.

Task 4: *Perform a soundscape analysis of the current environment*. In addition to the regular tracking, users will have the option to view a real-time update of their current noise exposure. It will provide them with relevant metrics including current dB, a recommended time limit, and any potential health benefits/risks presented by the soundscape.

Task 5: *Make a conscious effort to limit controllable sounds and spend more time in "zen" environments*. The app will emphasize behavioral changes over quick decisions and will include custom noise and zen goals that users can set.

Task 6: *Gain environmental awareness with crowdsourced data*. Users will have the option to anonymously submit their sound data into a database. This data will then be presented in a variety of different ways, including a "sound map" of various popular locations.

4. How are the tasks learned?

Tasks should be learned intuitively and in a way that relays high-level technical information in an easily consumable fashion. Upon first interaction with the design, a walkthrough will be presented to the user that gives a rundown of the design's features and shows the user how to complete the main tasks.

5. Where are the tasks performed?

Tasks can be performed in all settings with greater emphasis in areas of high levels of dB. Tasks also need to not be intrusive or cumbersome for the user as it should passively operate without input or interference from the user or external factors.

6. What is the relationship between the person and data?

The user will be given visual feedback about the amounts of noise exposed to for a given time period. The user and data will be linked using a personal device and data will be stored in a cloud infrastructure so it can be accessed at any given time. Since this data is personalized, each user will have personal access to their respective data. Data submitted to the database is done so anonymously and requires user permission.

7. What other tools does the person have?

There are plenty of software and hardware options that can accurately register decibel levels and range from phone apps to high fidelity sound meters. These are not common for individuals unaware of such technology as well as those who are not interested in knowing sound levels of a given space or time. As such, our design will differ in the fact that not only will the design provide the same capabilities as current tech, but also include personal informatics, prevention, and awareness features.

8. **How do people communicate with each other?**

   Users can communicate and compare their personal data using share buttons and social networks. They can also use their data to pinpoint and map out areas or times of high exposure since the data collected will be geotagged.

9. **How often are the tasks performed?**

   Task 1 will be performed continuously unless interrupted by the user. The remaining tasks will be performed at the users discretion, though at least once a day is expected. Newer users will be walked through how the product/technology works and will provide simple ways to use the product/technology.

10. **What are the time constraints on the tasks?**

    Each time the user checks the data, it will provide the data as soon as possible. How much time elapses depends on what the user wants to do with the data. At the most basic level, users should be able to perform task 4 as soon as they open the app. Other time constraints include displaying relevant information in a way that allows the user to gain insights at a quick glance.

11. **What happens when things go wrong?**

    Possible errors that could occur with the new system is failure to record at any given time due to either mechanical issues with microphones or hardware, or software runtime issues and failure to retrieve data. Standard app-related and software troubleshooting conventions should be taken in consideration. The product would ideally be running even when the device is on standby so it is somewhat under the mercy of the battery. Data should indicate when the product stops working for whatever reason.

Proposed Design Sketches - "3x4"

Design #1:

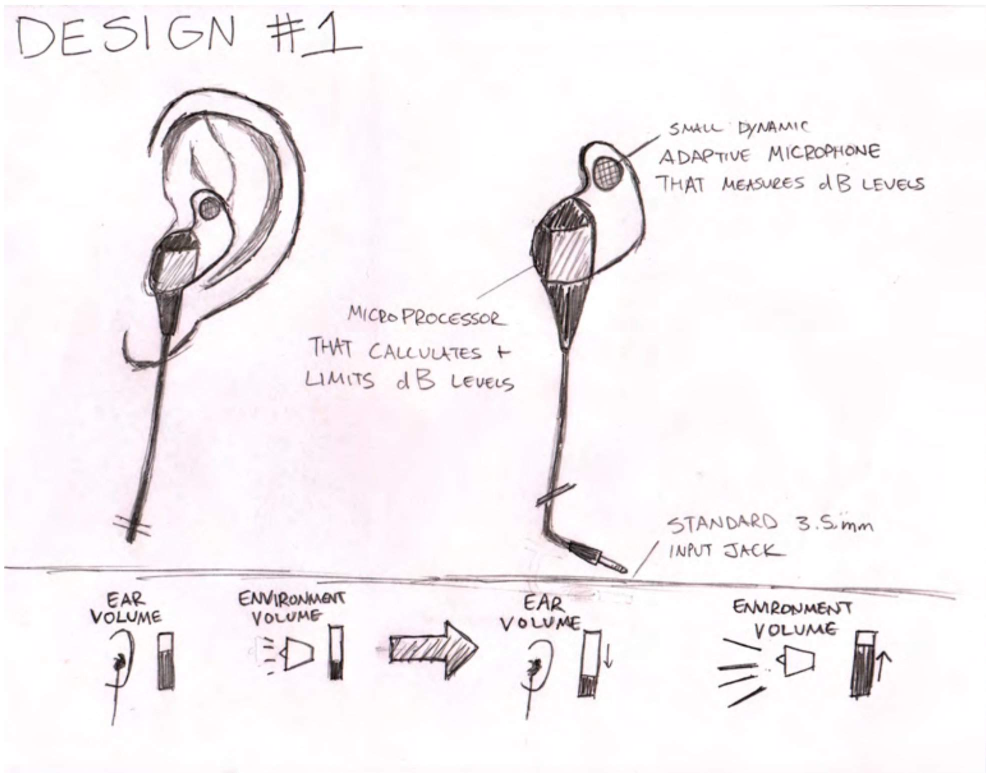


Figure 1: Design #1 Mockups

The first design is a set of earphones that adaptively change the volume of the output sound based on the sound levels of the outside environment. At the top of the earpiece, there is a small microphone that will actively capture the dB level of the surrounding environment (Figure 1). The main body of the earpiece itself consists mostly of a microprocessor that will receive sound data from said microphone and calculate the amount of sound allowed to the listener.

Our current six tasks are considerably different from the original six when this design was created. As such, this design only partially completes several tasks. For **Task 1**, it accurately measures yet doesn't record environmental sound for further analysis. For **Task 4**, it's constantly performing analyses of the current environment, but doesn't provide this information to this user. And for **Task 5**, it doesn't include any goals yet still allows users to limit the controllable sound of their own music listening habits.

Design #2:

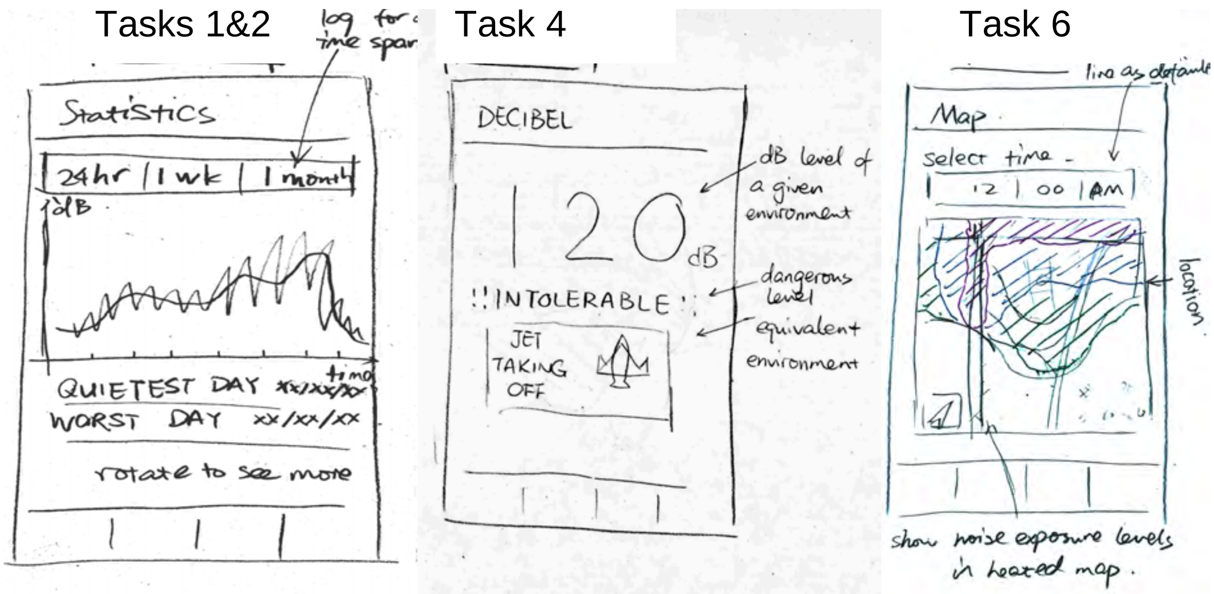


Figure 2: Design #2 Mockups

The second design is a phone app interface for our tasks. It will use the built-in microphone to record sound, and present the data on the phone's screen (as roughly depicted in Figure 2). As before, our tasks have changed, but this design still compares well to four of our tasks (as it should, being the design we chose for our project). On the left image, a graph of past data is displayed with a quick recap of quietest and loudest days in the adjustable timescale. This demonstrates **Task 1**, the measuring and recording of sound, as well as **Task 2**, a visual recap of the exposure. The middle image in Figure 2 is an implementation of **Task 4**, as it performs a perfunctory analysis of a (very loud) environment, shows current dB, and displays a relatable noise comparison. The right image shows a possible depiction of environmental awareness from a crowdsourced sound map (**Task 6**).

Design #3:

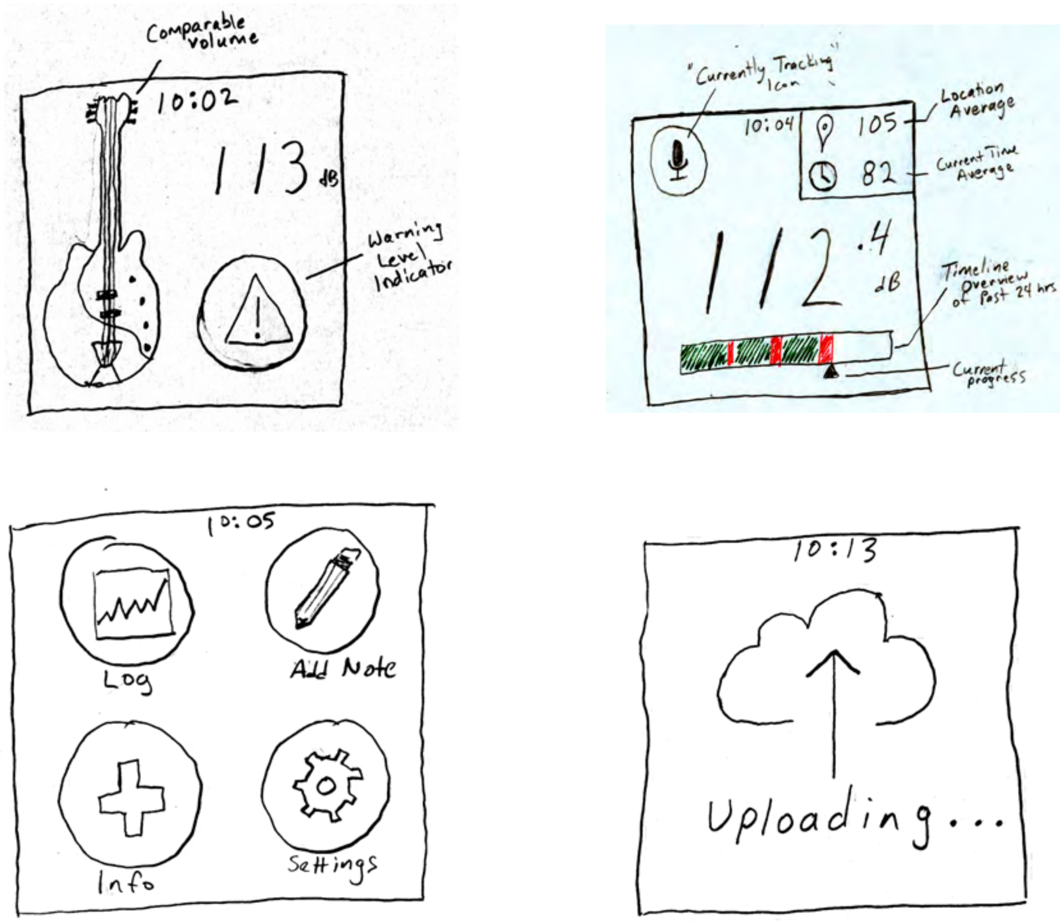


Figure 3: Design #3 Mockups

Our third design delves into the possibility of using a wearable device to help track sound. This could be an ideal implementation for many reasons. Unlike a phone, a watch would rarely be kept in a pocket or backpack and be completely exposed to environmental noise nearly 24/7. The diagrams shown in Figure 3 are based loosely on the iWatch screen dimensions and UI, but these could easily be adapted to similar interfaces. The images match up with Tasks 1, 2, 3, and 6. In the top left we see the watch in it's default screen. The "113 dB" is proof that the watch itself is taking a measurement of environmental sound (**Task 1**). Though the top right photo is primarily showing current dB, in the bottom part of the image you can see a time bar of past exposure, a visual recap (**Task 2**). Bottom left of Figure 3 shows the option to view health info regarding your exposure (**Task 3**), and the bottom right shows the screen when the watch is uploading user data to the sound map database (**Task 6**).

Choice of Design:

The design we chose to pursue was a smartphone application (Design #2). The headphone design idea was an interesting approach during our first ideation, yet doesn't provide nearly enough functionality for our newer tasks. The smartwatch application is quite promising, but that technology is only just starting to enter the market and the vast majority of our users would be forced to purchase a device to use our design (no good). Also, the battery of such a device would unlikely be able to last an entire day and still maintain frequent sound readings. That said, it would be intriguing to look at this design possibility in several years, perhaps as a companion app to our final design.

The design we chose was our Design #2, a smartphone application. The fact that most of our potential users own a smartphone and we can use the built-in microphone means that users are not required to purchase extra hardware for the tracking functionality. This is hugely important and something that all of our contextual inquiries addressed. The screen provides a clean way to present the data and will allow users to check the analysis at virtually any time during their day. Though a web-based interaction with the data might be worth looking into. One main task to explore is Task 5, giving the users an interface to set goals and make conscious behavioral changes. Additionally, our implementation of Task 2 is critical. Because we are limited by screen real estate, it will be difficult to display detailed information and keep it legible. We must ensure that users can glance quickly at their data and be able to draw important conclusions regarding their soundscape without much effort.

Written Scenarios - “1x2”

Scenario 1:

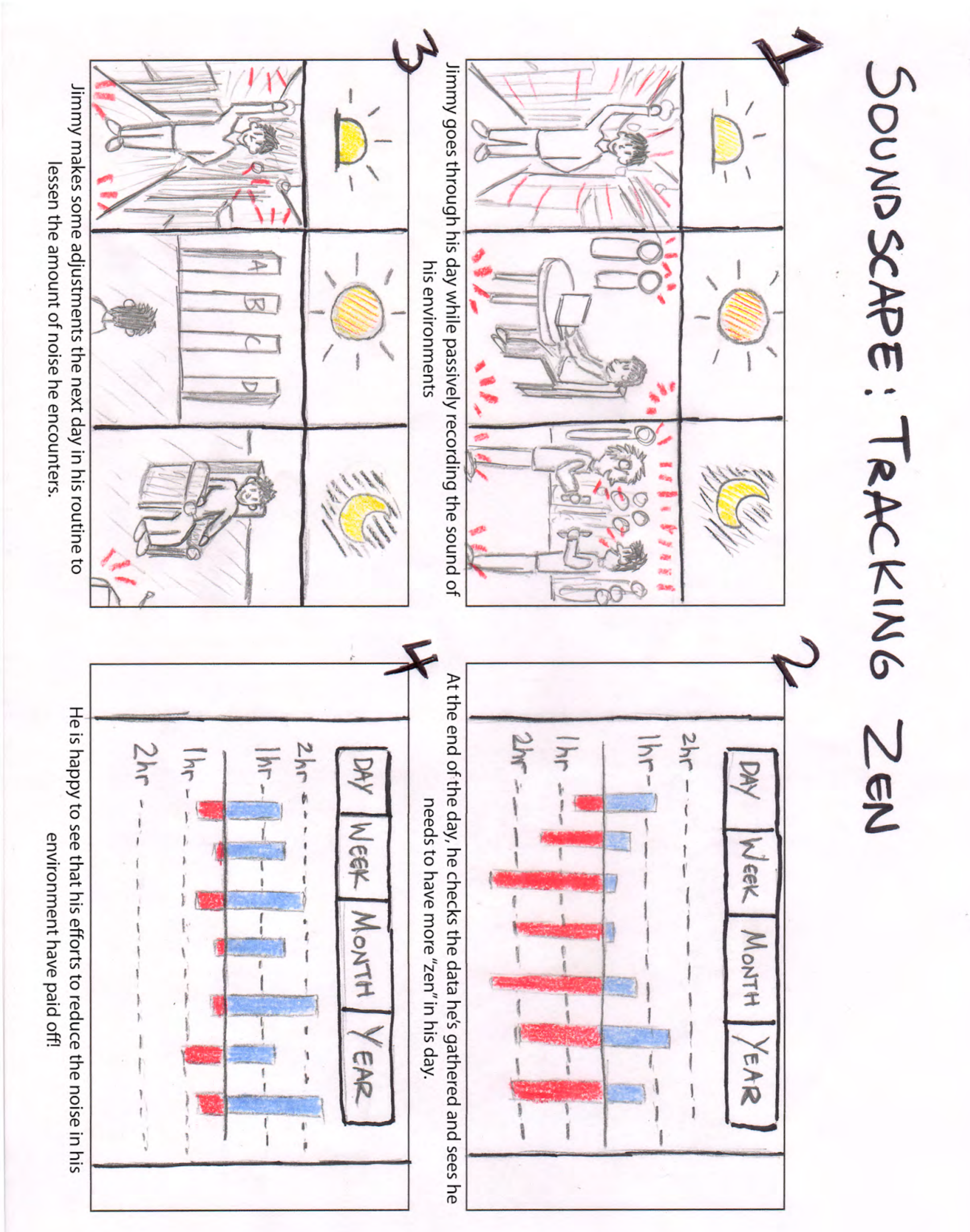
In the first scenario: Soundscape: Tracking Zen, the storyboard emphasizes the function of Task #2 and follows a student Jimmy, who in the first panel, goes through his day while passively tracking his noise exposure through his mobile phone. Jimmy is an aurally conscious individual and has already set up his app to covertly record his surroundings in addition to the information he has enter regarding his family history of hearing loss as well as any personal thresholds. He notices that there is quite a bit of noise wherever he goes, but he lets his phone do all the tracking for now and takes mental notes of the types of locations and sounds he encounters. After a week of data collection (panel 1), he checks the data he has recorded and sees that his days were filled with lengthy periods of time exposed to potentially dangerous levels of sound (panel 2). He recalls the locations that may have influenced this data and thinks about ways to improve whether it be through complete avoidance of said areas, or trying to increase the amount of “zen” he experiences per day. In panel 3, he demonstrates behavioral changes by making conscious decisions about the environments and the respective noise levels around him, such as studying in a library as opposed to a noisy cafeteria. After several days of this new awareness and changes to his aural soundscape, he checks his data once again to find that he has drastically improved the amount of “zen” intervals in his day and consequently feels accomplished (panel 4).

Scenario 2:

Our second task, “ Soundscape: Exposure Analysis”, outlines the goals and procedures of Task #3 and details the health information that is provided via data analysis of the noise and “zen” levels of a user. In the first panel, an example Jimmy’s data is depicted with contrasting colors of blue and red to differentiate between the good and bad sound levels he has experienced. If Jimmy would like additional information and more in-depth analysis of the types of information he is passively gathering, by pressing the analysis icon in the lower right corner, he is presented with a visualization of the accumulated data from his collections. This split-screen orientation juxtaposes “zen” with exposure, giving a black versus white type of representation to the quality of data that Jimmy has collected over a period of time. Jimmy is then given the option in the second panel to either swipe left or right which will give him more information and insights about his zen or exposure levels respectively. In addition, the app will display the health benefits and detriments of exposure and “zen”. For excess exposure, the app will give the potential health risks of his exposure as well as tangible simulations of hearing loss based on his data. Conversely, the app would also show him that by increasing “zen” levels, he is boosting productivity, bolstering his immune system, reducing stress, and increasing his general well-being (seen in panel 3).

Storyboards

Soundscape: Tracking Zen



Soundscape: Exposure Analysis