Early Sense Live Design Assessment

Contents

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Final Project Specifications
12/10/2018

Conceptual Model

The EarlySense Live application is used in conjunction with a physical sensor device that is placed underneath your mattress. The device analyzes sleep cycles and monitors health while the user sleeps. It sends real-time updates of descriptive statistics about sleep stages, heart rate, breathing rate, stress level and movement to the application as you sleep. EarlySense was originally created to better support general care patients during their hospital stays but today, it is being used and marketed outside of hospitals to health-conscious adults, parents of small children and family members of senior citizens.

The application strives to present the sleep statistics and health information in easily digestible formats such as graphs, charts and other easily digestible information. However, the application fails our users in terms of easy navigation, explanation of sleep metrics, and understandable graphical display. With this project, we hoped to analyze the pain points of the application and redesign it to better serve its users.

Project Scope

The scope of our project was to first understand users and their tasks when using the current application. Following this, we developed some design plans for key pain-points within the existing system, and implemented a prototype using Adobe XD to demonstrate the proposed changes to the existing application. The prototype was further analyzed through a usability inspection involving other students in the SILS department at UNC, and further modifications were proposed for the prototype and actual system based on the feedback we received. The following points summarize the limitations and scope of this project.
This prototype developed in this project is only semi-functional, with some implementation only in key areas we identified needed redesign. Implementing a fully-functional prototype or application was out of scope for this project.

System Goals

Our goals for the redesign of this system include:

- Make it easier and more intuitive for users to monitor the changes in their sleep quality over time.
- Allow users to find information about their vitals and sleep metrics easily and communicate that information to them in a manner that they can understand.
- Simplify navigation throughout the application so that users can find the information they need where they would first expect.
- Simplify graphical displays within the system to be easier to understand, as well as easier to interact with without disrupting other tasks.

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Final Project Specifications
12/10/2018

User Analysis for EarlySense Live

User Group Description:

This user interface is the device, EarlySense Live, which analyzes sleep cycles and monitors health while the user sleeps. This device consists of a white monitor that is placed under the mattress and an application that displays the statistics and sleep patterns the device captures. EarlySense was originally created to better support general care patients during their hospital stays. Since general care patients were not in serious conditions, their vitals were monitored less often (once every 4 to 6 hours). Studies found that a lack of constant monitoring increased complications. The EarlySense was created as an alternative to complex monitoring technology such as sensors and cuffs. Today, the EarlySense is used and marketed outside of hospitals. Users at home are using EarlySense to monitor their sleep patterns, check their vitals and safeguard their children/elderly relatives[1].

The user group of this product is very diverse since the product can be adapted for different uses. It includes general care patients in hospitals, senior citizens, adults who experience sleep apnea/other sleeping issues, people who are interested in monitoring their own health data and parents who are concerned about their children's sleep/health[1,2].

User age varied but is primarily middle-aged to older adults. We believe few teenager/young adults will use this system since they generally do not have sleep or major health concerns. Additionally, those who are using the device to monitor their children's sleep will be adults, primarily their parents. Gender is not a primary factor as all genders are able to take advantage of this system. The group contains users with physical or motor disabilities since it is used to monitor health, but it also includes physically fit and able people who simply wish to track their health data[1].

There is a range of education level, but it can be assumed that most users have at least a high school education and a proficient reading level. To use the device, the user must be able to read and analyze graphs and understand English. In terms of specific medical terminology, it is common for users to have a limited understanding of some of the statistics and vitals the EarlySense Live tracks. This may be their first introduction to these terms especially if they do not have sleep/health problems or they have just begun to show symptoms. Therefore, visualizations of the data and simple definitions of measurements are essential for the success of the device[1,2].

The level of computer/IT experience varies but users must be comfortable and able to download and navigate an application as well as sync the device to the app. For middle-aged adult users, they will have a proficient or advanced computer literacy, but older adults may need more guidance. All users will have some experience with applications and Internet usage, but their level of their proficiency will vary. Users will have little to no experience with similar systems since they have either just developed symptoms or are using the device to monitor low-level conditions. It is possible that older patients may have used higher-grade and more complex vital tracking devices, but these would be used by their nurses or doctors. Users will have had experience in tracking of vitals through doctor visits or hospital settings but likely will never have encountered a device like this before[1,2].

Most users will be externally motivated by sleep or health problems that prompted them to use this device. Thus, they are hopeful that the monitoring of their vitals and sleep patterns will help

resolve their problems. This may mean they are frustrated with their current health condition and are desperate to find a solution. Alternatively, they may just be curious about the quality of their sleep and are hoping the EarlySense Live will provide them with novel insight[1].

Checklist of Important User Characteristics

The checklist below is a list of types of key characteristics across our different user groups, as well as the likely or expected value of those characteristics in our key user groups.

Characteristic Type	Expected value in Key User Groups
Physical Characteristics	
Age	30 – 55
Handicaps/Perceptual Disabilities	May have some, but not necessarily
Physical Disabilities	May have some, but not necessarily
Weight, Height, and BMI	Often overweight to obese
Other health concerns	Typically related to sleep.
Lifestyle Characteristics	
Activity level and diet quality	Usually poor, but not necessarily
Stress level	Often high
Sleep quality, regularity and amount	Poor quality, irregular, minimal sleep
Social/family life	Often strained by lack of energy.
Regularity of Doctor Visits	Often irregular or less than needed
Psychological Characteristics	
Motivations to use system	To meet health, career, and social goals.
Motivations and attitudes towards health	Willing to improve but lack of direction
Goals and Frustrations	Often related to poor sleep and its impact on career, family, and health.
Knowledge and Experience	
Education and reading level	Educated and well read, including ability to read charts.
Experience with technology	Comfortable with technology
Medical terminology and nutrition/wellness knowledge	Limited medical knowledge, often some nutrition/wellness knowledge
Native language	English

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Final Project Specifications
12/10/2018

Personas

We have developed 4 personas, 2 primary and 2 secondary personas, based on both the analysis of users from EarlySense, as well as an analysis of common themes across customer reviews on Amazon[2]. The personas can be further divided into 2 types: those who want the device for their own use, or those who want it to monitor others, where there is a primary and secondary persona for each type. A short description of each of these personas is below, along with the name of their corresponding persona:

Primary Personas:

- An individual with extensive sleep problems and poor health related to those sleep issues and would be motivated to use EarlySense to better understand the problem. Represented by our persona, "Andy".
- An individual who is a healthcare practitioner or manager of a healthcare facility, who would like to better monitor the vitals of general care patients. Represented by our persona, "Deandra"

Secondary Personas:

- An individual who is overall quite healthy and proactive with keeping up with their health issues and wellness but has minor sleep issues and would be motivated to use EarlySense to monitor them. Represented by our persona, "Haley".
- An individual who is looking to monitor the sleep of his/her child, due to some issues they are having, and would be motivated to use EarlySense to do so. Represented by our persona, "Beth".

Complete personas listed above can be found on the following pages. Images used are no attribution required (cited below in references 4 through 7 with respect to the order the personas appear).

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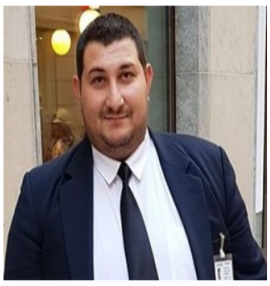
12/10/2018

Andy



"I'm Exhausted all the time. Tired at work, tired when I get home. . . I wake up and I'm already tired."

Age: 47
Gender: Male
Education: M.S., Computer Science
Occupation: Software Engineer
Family: Wife and 2 children.
Native Language: English

Personality

Introvert — Extrovert
Thinking — Feeling
Sensing — Intuition
Judging — Perceiving

Knowledge and Aptitudes

Computer Literacy
Reading Level
Medical Knowledge
Nutrition and Lifestyle Knowledge

Goals

- Monitor his sleep and other related health issues nightly to understand why he is experiencing problems.
- Find ways to take steps to improve sleep quality and overall health.
- Be more energetic throughout the day to improve his work ability and his relationship with his family.

Frustrations

- Struggles to sleep peacefully many nights, which affects his health and ability to do his work effectively.
- It is difficult to determine what is wrong with his sleep because he is in and out of consciousness when the problems occur.
- Available solutions of visiting sleep clinics are costly, time-consuming, cannot be done regularly, and can't be done in the comfort of his own home.
- Due to his sleep issues, it is difficult to sleep next to his wife as he often disrupts her and she makes him sleep on the couch. iagss85p
-

Bio

Andy has been struggling with sleep apnea for most of his adult life, and it has only gotten worse with age, compounded by other issues such as high blood pressure and obesity. He has tried improve his condition with CPAP but has found it to be very uncomfortable and unhelpful so he no longer uses it.
His struggle with sleep apnea and constant exhaustion has taken a toll on many facets of his life: from his work to his family and social life. He had hoped that by this age he would have been a software project manager at the company he works for, but he has been unable to muster the energy to work his way up the ladder. His health issues have also put a strain on his family, particularly for his wife, who can no longer comfortably sleep beside him in the same bed due to his snoring and restlessness.
His doctors have been telling him for years that his best option is to start losing weight, which he has tried to do but has failed to stick to an effective weight loss regimen. He also feels that his doctors might be basing their diagnosis on statistics and are dismissive of his specific concerns and needs. He has tried to deal with specialists in the past by going to a sleep clinic, but he felt very uncomfortable sleeping outside of his own bed so he did not continue the therapy.
As a lover of technology with an aptitude for working with and trying out new devices, he feels that a device which can track his vitals and sleep issues and record data that he could understand himself would help him figure out what his issues really are and how he can work to improve them.

Motivations

Improve Healthy Habits
Visit the Hospital
Try New Technology
Build Career
Improve Family Relationship

Medical Traits

Weight: 210 lb (95 kg)
Height: 5'8 ft (173 cm)
BMI: 31.9 (Obese)
Physical Disability: none
Handicaps: none

Physical Activity

Sedentary — Active

Nutrition

Unbalanced — Balanced

Stress

Low — High

Social Activity

Solitary — Outgoing

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Final Project Specifications
12/10/2018

Deandra

"Our non intensive-care patients need a way to get regular monitoring that isn't too invasive."

Age: 44
Gender: Female
Education: B.S. Biology, M.D. Internal Medicine
Occupation: General Practitioner
Family: Married
Native Language: English

Personality

Introvert — Extrovert
Thinking — Feeling
Sensing — Intuition
Judging — Perceiving

Knowledge and Aptitudes

Computer Literacy
Reading Level
Medical Knowledge
Nutrition and Lifestyle Knowledge

Goals

- Better support general care patients during their hospital stays
- Be able to give general care patients more comfort during their stay without having to take resources from intensive care patients.
- Have a better system to track the vitals and needs of general care patients, especially as patients sleep, that isn't personnel/resource intensive.

Frustrations

- Knows that general care patients at the hospital feel under-served and uncomfortable during late hours and doesn't have the tools or nursing staff to help them.
- General care patients who feel uncomfortable often want to leave the hospital much earlier than they should.
- Cannot simply move a lot of nursing staff to work on general care patients during the night because they need to attend to patients with more serious problems and intensive care needs.

Bio

Deandra is a general practitioner at a busy hospital that beds many general care patients and intensive care patients overnight, with limited nursing staff to support them all. Often this means that nursing staff at night almost all attend to intensive care patients, with minimal monitoring of the needs for the general patients who are staying overnight. General care patients are typically hooked up to multiple medical apparatuses to keep track of their vitals, and while some are completely necessary, others do tend to cause unnecessary discomfort. This is an issue for Deandra's patients as they often complain and want to leave the hospital much earlier than what she recommends. She cannot unhook her patients from monitoring devices because they need them, but wishes they were more comfortable to use so that her more sensitive patients could get enough rest.
Deandra had also hoped that the hospital would work on staffing more nurses during the night, as she knows a lack of regular monitoring can lead to more difficult complications, which she often has to be called in to deal with. However, the hospital management has told her that they won't be able to do so for the time being and she should try to find some more creative solutions to help patients have a more comfortable and well-monitored experience.
As a doctor, Deandra has extensive knowledge in medical terminology and issues. She also has a lot of experience with technology, especially related to medical devices for at home and in hospital use. She is very fond at trying different devices so that she can recommend them to her patients if they have specific issues, because as a GP she really wants to encourage her patients to regularly monitor and take good preventative measures for their own health.

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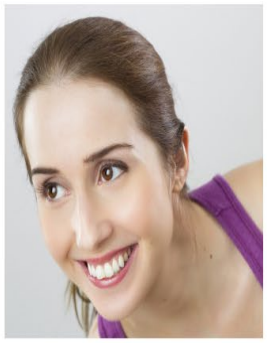
Final Project Specifications
12/10/2018

Haley



"I do my best to have a balanced and healthy lifestyle, but with all the work I have I don't get much sleep."

Age: 33
Gender: Female
Education: B.S., Business Administration, pursuing a PG.Dip. in College teaching
Occupation: Marketing Manager
Family: Boyfriend and 2 dogs.
Native Language: English

Personality

Introvert — Extrovert
Thinking — Feeling
Sensing — Intuition
Judging — Perceiving

Knowledge and Aptitudes

Computer Literacy
Reading Level
Medical Knowledge
Nutrition and Lifestyle Knowledge

Goals

- Get the best out of the limited time she gets to sleep.
- Prevent major health concerns by regularly monitoring vitals to discover issues before they become serious.
- Maintain healthy habits and overall well being as she ages.

Frustrations

- Gets limited sleep due to all of her daily duties and activities
- Has a detail-oriented mindset and need to keep track of her health and fitness, but finds some sources for doing so to be unreliable, or unavailable.
- Doesn't know if getting fewer hours of sleep is taking a serious toll on her long-term health.

Bio

Haley has always been thinking ahead and trying to stay on top of every facet of her life: from keeping up with friends, to building her career, and maintaining good health. While she's been quite successful on all fronts, she still struggles at times to balance all of her duties and activities, and as a result she tends to not get enough sleep. While some coffee in the morning usually does the trick to give her enough energy to get through the day, she does have concerns with how this will affect her health in the long-term. As she's nearing her mid-30's, she's began to realize that her body can't take as much stress as it used to, so she wants to make sure she's doing what she can do to prevent any serious health issues. She doesn't give herself much flexibility to take on less work or activities and get more sleep, so she would ideally like to improve the quality of what little sleep she may get at times. Otherwise, she would like to understand how much of a toll limited sleep is taking on her health, which may motivate her to take more time to rest.

She does visit her doctor regularly, gets enough physical activity, and most often takes care of what she eats. While this sort of lifestyle will give most people a sense of comfort that they are taking good preventative health measures, it's not enough for Haley. As a very detail-oriented person who likes to plan her days out extensively, she isn't satisfied with something as important to her as her own health having too much uncertainty. She feels embarrassed to bother doctors with her concerns, who often dismiss her as being overly worried about nothing. She would instead like to have a way to keep track of her vitals on her own, especially related to her sleep, since she isn't getting enough.

She already owns several digital health devices, such as a Fitbit, a smart scale, and digital blood pressure monitor, as well as several health related apps that she uses to track calorie intake, exercise, and more. She's very comfortable with using and trying out any sort of health device she can get her hands on, so long as it does something a device she already has doesn't do.

Motivations

Improve Healthy Habits
Visit the Hospital
Try New Technology
Build Career
Lighten her Schedule

Medical Traits

Weight: 124 lb (56 kg)
Height: 5'5 ft (165 cm)
BMI: 20.6 (Normal)
Physical Disability: none
Handicaps: none

Physical Activity

Sedentary — Active

Nutrition

Unbalanced — Balanced

Stress

Low — High

Social Activity

Solitary — Outgoing

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Final Project Specifications
12/10/2018

Beth

Above: Beth (left) and her son, Max (right)

"I didn't pay enough attention to my son's sleeping needs, and I'm paying the price for it now."

Age: 39
Gender: Female
Education: B.S. English, J.D.
Occupation: Corporate Attorney
Family: Divorced, one son
Native Language: English

Personality

Introvert — Extrovert
Thinking — Feeling
Sensing — Intuition
Judging — Perceiving

Knowledge and Aptitudes

Computer Literacy
Reading Level
Medical Knowledge
Nutrition and Lifestyle Knowledge

Goals

- Hopes to better understand why her son developed behavioral insomnia and how it is harming his health, school performance, and mood.
- Would like to find methods to improve her son's condition that encourages bonding rather than obedience and disciplinary action which strains their already difficult relationship.
- Prefers the new methods to be well integrated into the rest of her and her son's life and not come at the cost of a time she doesn't have.
- Hopes improving her son's sleeping patterns will improve his mood, his school performance, and his relationship with her.

Frustrations

- Has an intense career which makes it difficult to manage her son's needs, especially after separating from her ex-husband.
- Her son has developed behavioral insomnia due to lack of having a schedule and healthy sleeping habits, which is poorly effecting his health, academic performance, and his mood.
- Feels that steps she has tried to take to improve her son's issues have not been as effective as she had hoped, and have strained their relationship.

Bio

Beth has an immensely busy life trying to balance her career as a corporate attorney as well as being the single mother of her 6 year old son, Max. As a recent divorcee, she struggled to provide her son with the attention he needed to develop a healthy schedule and habits, and she's hoping she can take steps to rectify that now that her separation from her ex-husband has been settled. Possibly due to this (and perhaps some other factors), Max has developed behavioral insomnia, a condition where he has developed behavioral tendencies that cause him to have reduced and poorer sleep than he needs. This condition has negatively affected his energy levels and mood, which has been noticed by his school teachers who asked Beth to take more time to deal with it.

She has already tried various methods to get Max to go to bed when he needs to and get enough sleep. Many of these methods have involved technology, which she has become very comfortable with over the past few years. She figured out how to use parental controls on devices in order to keep him off them when it's time for bed, she uses Google Home to turn off the lights at bedtime, and uses other digital task managers to schedule mealtimes and reminders to get herself and her son on a healthy schedule. While these methods have worked to some extent, they have also put a strain on her relationship with Max, who feels she is being too controlling and disciplinary.

Beth would like to find or develop a way to get Max to sleep better that doesn't involve plain discipline. Max loves all kinds of games, so Beth thinks that a method that involves rewarding max for good sleep and turning sleeping well into a game could really change his attitude towards it. However, it's difficult for her to develop something that would seem fair or fun to Max, since she can't possibly monitor and score his sleep every night on her own.

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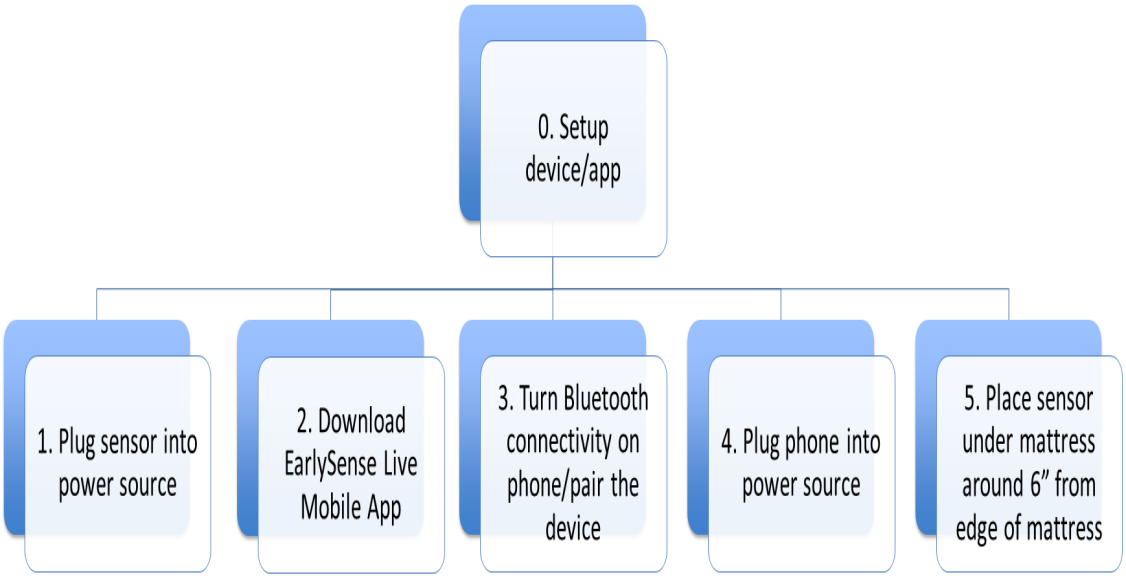
12/10/2018

Task Analysis for EarlySense Live

Task 1: Connecting the Device and Application

Hierarchical Description



Essential Use Cases

ConnectDeviceToApp

USER INTENTION	SYSTEM RESPONSIBILITY
Plug device (sensor) and phone into power source	
	Enable Bluetooth capability on phone
Download EarlySense Live mobile application from App-store	
	Detect device with phone application
Place EarlySense device under mattress	

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Final Project Specifications
12/10/2018

Scenarios of Use

Connect Device to Application

- Haley is setting up her new EarlySense device. She takes it out of the packaging and connects it to a power source. She already has Bluetooth enabled on her phone, so she simply pairs with the device to connect it to her smartphone. Then she places the sensor 6" from edge of her bed under her mattress.
- Andy is setting up his EarlySense device on a new phone. He already has the device setup and under his mattress, so he sets up his phone's Bluetooth, and pairs the device to the new phone after the prompt appears on the app.
- Deandra is setting up an EarlySense connection to monitor one of her patients, after the patient agreed to do so. She has her patient bring the device in, uses Bluetooth to connect to it, and both she and her patient accept the prompt on their phone application to allow Deandra to receive her patient's data from the device.

General Description of Task Characteristics

The task of setting up the device and mobile application, for most users, is a one-time task, but may be repeated if a user wants to connect the device to several mobile phones, which can be done up to five times. There are no real time-constraints on performing this task.

The task is not very complex and is supported by a simple tutorial that can be found both within the device box manual, as well as on the application when installed on the user's phone. The tutorial offers a step-by-step guide on how to set up the device under the mattress, connect it to the phone app via Bluetooth, and set up your user account settings. Users can return to the previous steps in the guide at any time if they feel they made a mistake and can also access the guide using the physical manual or using the mobile application at any time.

This task is mandatory to perform at least once to use the device. Beyond just starting the device, the steps educate the user on how to continue using the device effectively, such as making the user aware of different settings, and how they need to keep their phone close enough to the device to take readings.

The task is performed in the user's bedroom as it involves placing the device under the mattress. The user should have a nearby electrical outlet to plug in the device.

Setting up the device also serves a secondary purpose if the user wants to have it connected to other people's devices. It can allow up to 5 users to connect to the same device to track the vitals of a single user and receive reports.

If anything goes wrong during this process, the user can go back through the instructions for review or contact the EarlySense customer support.

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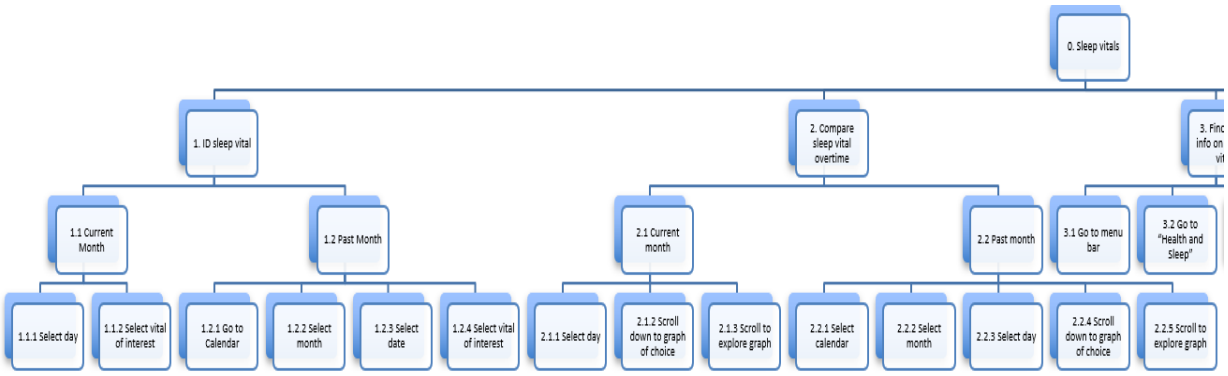
Final Project Specifications
12/10/2018

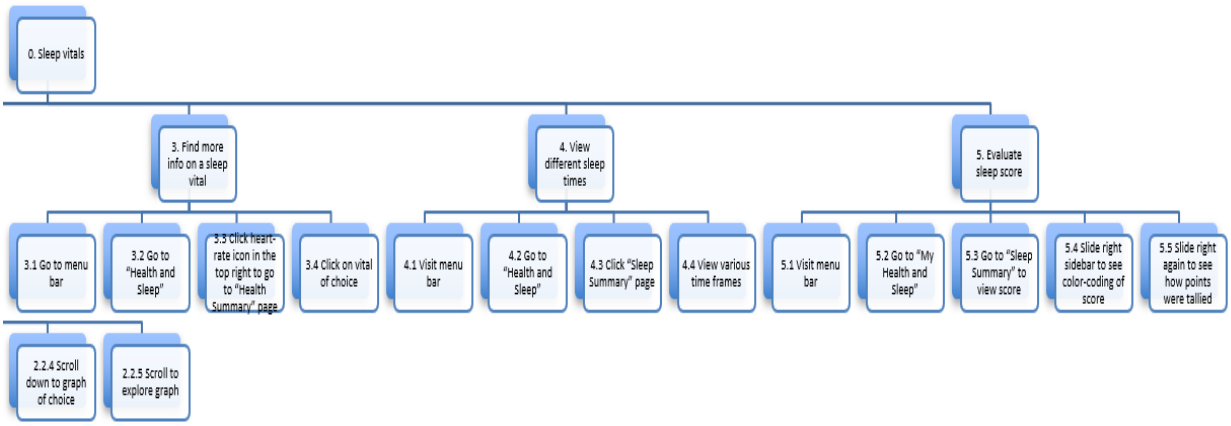
Task 2: Viewing Sleep Vitals/Data

Hierarchical Description

Part 1:



Part 2:



Essential Use Cases

FindDailySleepVital

USER INTENTION	SYSTEM RESPONSIBILITY
Find vital information on daily display	
	Record vital information on phone app
View basic vitals and graphs.	
	Display information in various graph formats
Check sleep score stats	
	Store sleep data, calculate, and display scores

CompareMonthlyVitals

USER INTENTION	SYSTEM RESPONSIBILITY
Select desired month to compare	
	Display calendar by months.
View vital data over the month	
	Store all past data by date. Display Information in various graph formats
Look for details of interest on graphs	
	Allow users to zoom in on data and scroll across data in graphs.

ViewDifferentSleepTimes

USER INTENTION	SYSTEM RESPONSIBILITY
View possible sleep times on daily display	
	Record sleep statistics any time the user is sleeping (at night, naps, etc.)
Select desired sleep time	
	Record and display vital information
View basic vitals and graphs	
	Display information in various graph formats
Check sleep score stats	
	Store sleep data, calculate, and display scores

Scenarios of Use

Find Daily Sleep Vital

- Andy is interested in knowing his heart rate and breathing rate. He goes to the main menu, selects “Health and Sleep”, and then clicks on the heart rate icon at the top-right corner to go to the “health summary” page. This page provides information on heart rate, breathing rate, stress, and sleep activity for his past night. Andy was first interested in his heart rate information, but while on the summary page he finds information that his stress level is higher than he originally thought.
- Beth finds her son Max is quite restless in the morning, so she wants to check whether he had any issues during sleep last night. She goes to the main menu, selects “Health and Sleep”, and then clicks on the heart rate icon at the top-right corner to go to the “health summary” page. Now that she is viewing the “Sleep Summary Page” for Max’s last night of sleep, she can see that he has a low sleep score of 54. She swipes across the vital chart on the right of the page to view how the score was calculated and finds that her son spent only 4 hours asleep and woke up several times throughout the night.

Compare Monthly Vitals

- Andy has been trying an improved diet and exercise regimen for a month now and wants to see if this has improved his quality of sleep. He visits the calendar from the main menu and can see all the sleep data together for the current month. He scrolls down through

each of the graph displays and swipes across each of them to see the changes in vitals. He notices that his heart rate was much higher early in the month, at times reaching abnormally high rates for sleep, but has gotten more stable towards the end of the month.

- Deandra wants to develop a basic report on one of her patient's vitals over the past few months to let the patient know if there has been long-term improvement in their obstructive sleep apnea (OSA) issues. She visits the calendar from the main menu and views scores from 4 months ago first. She records some data points from each of the graphs, then goes to 3 months ago, then 2 months, then the current month, doing the same each time. She finds that the patient has initially improved sleep quality, breathing, and heart rate for the first 3 months, but then in the past month has declined in health quality across these metrics, and that the patient's stress levels appeared to be higher than normal on most days. She uses this data as an opportunity to discuss some recommendations for reducing the patient's stress.

<u>View Different Sleep Times</u>

- Haley wants to know how much times she spends in bed. She goes to the menu bar and selects "Health and Sleep". Under the "Sleep Summary Page" she clicks on the time frames above the graph. The app displays the amount of times that Haley was in her bed. She can see when she was napping, relaxing, and sleeping in her bed, and swap between each time to view vitals.

General Description of Task Characteristics

This task can be best divided into two key subtasks: those that involve daily vital tracking, and those that involve comparing vitals and sleep data over longer periods of time. For the first task, the user can view sleep data daily in the morning after waking up, to see how their sleep scored that night. To compare sleep vitals over several days, the app is restricted to viewing these month by month in graph form, and the user will have to accumulate data over several days consistently to generate good graphs.

This task ranges from simple to complex and difficult depending on how much details the user needs. If the user is only looking for daily vitals and sleep scores, the task can be viewed and understood within seconds. If the user wants to get more details on how the sleep score was calculated, and understand overall sleep activity that night, it will take more time to view the data and understand it. Finally, if the user wishes to compare data over the course of a month, the user is limited to graphical data which can take some time for some users to understand.

Vital tracking and viewing can mostly be done on a single page within the application, if it is for daily viewing, but must be viewed on the calendar for comparing the data over time. Tracking vitals is discretionary, but also the main purpose of this device and application, so users may want to do so regularly. The device will still track and store data on vitals so long as the phone is kept near the device, and the device is plugged in and beneath the mattress, so if users do not check their vitals regularly, they could still do so later and get the same information.

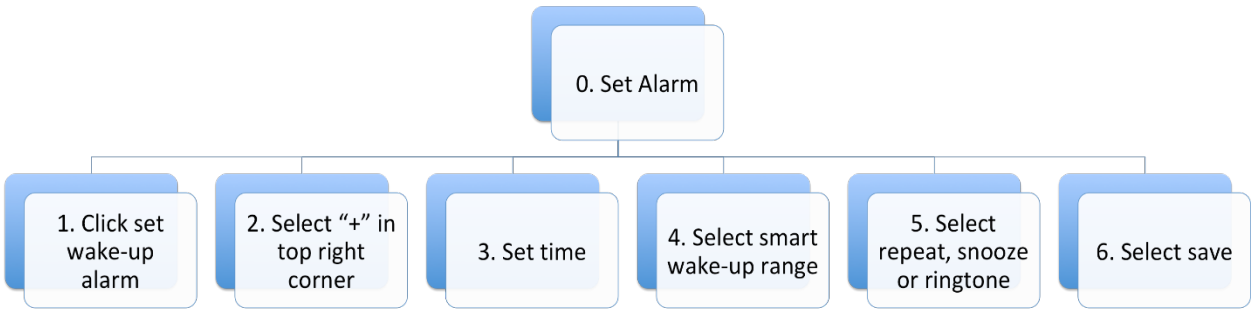
This task can be performed from anywhere, since the data is stored on the phone even after the user wakes up and leaves the bed. The user only needs to keep the phone near the device while they plan to track their sleep.

Tracking sleep vitals can also be performed by other users who are connected to the device, such as a doctor monitoring a patient or parent monitoring their child or elderly loved one.

The application does offer some information on what the vitals mean and how to read the data provided, but there is still a lot of learning users need to do themselves, and some of that learning may need to be external to the device and application. Users can better familiarize themselves with medical terminology and reading graphical data to understand how to interpret what they see. Like most medical devices, users should expect to refer to a doctor for more serious medical concerns that may arise, as the device cannot provide the information needed to fully understand those conditions. Mistakes in interpreting the data can give users a false sense of relief or fear, depending on how the data may have been skewed.

Task 3: Setting the Alarm

Hierarchical Description



Essential Use Cases

SetAlarm

USER INTENTION	SYSTEM RESPONSIBILITY
Create a new alarm	
	Display + button to allow a new alarm to be created.
Set date and time for alarm. Select whether to use smart wake-up range for time.	
	Display and store date and time. Use sleep data to determine smart wake-up time
Add the alarm and see that it is on	
	Set newly created alarm to "on" by default

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Final Project Specifications
12/10/2018

Scenarios of Use

Set an alarm

- Andy needs to set an alarm. He clicks "set wake-up alarm" on the front page of the EarlySense application. He selected the + sign in the top right corner which takes him to a new page where he can set the alarm. He sets a smart wake up range for 30 minutes, so his alarm is set between 7:00am-7:30am. Finally, he selects save.

General Description of Task Characteristics

This task, if performed, will likely take place once during the setup of the user's device, or some other time early during the device's use. Users may return to this task if they wish to setup a new alarm, edit, or delete an existing alarm.

The task is simple and has a very similar structure to other alarm applications: users can first create a new alarm or edit an existing one, enter the time and dates the alarm should go off, and save. The additional feature is that the alarm is integrated with the device and has a "Smart Wake-up" feature which allows users to choose an interval of time where the device can wake them up, based on when the user is in a light sleeping stage. The page for alarm setup has this feature displayed, which is simple to setup, but the page does not explain how it works.

This task is not mandatory, and many users will likely rely on other sources for alarms (physical clock alarms, or other mobile apps). Only the smart wake-up feature heavily requires the device but does not involve any of the other key tasks.

Setting up the alarm can be done from anywhere on the mobile application, but having it work requires the mobile to be placed within a hearing range, and additionally within range of the device to use smart wake-up.

The alarm can only be setup by the main device user, not by other users tracking the device and vitals. The application tutorials do not cover use of the alarms, but the user manual provides information on how the smart wake-up feature works. If anything goes wrong with the alarm, users can adjust the settings or delete their alarms.

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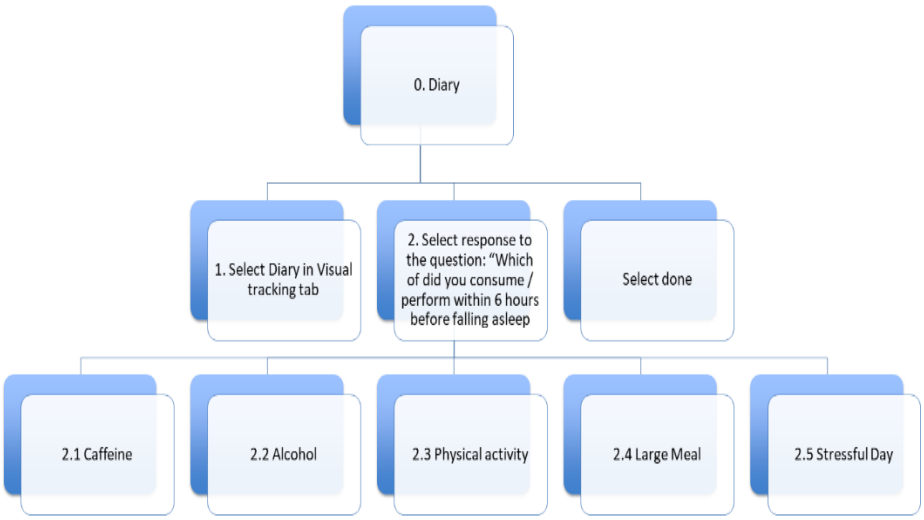
12/10/2018

Task 4: Using the Diary

Hierarchical Description



Essential Use Cases

InputDiaryData

USER INTENTION	SYSTEM RESPONSIBILITY
Answer diary questions	
	Display diary questions for each day, and allow them to be answered (clicked for yes/no)
Save Diary	
	Store diary information
Review Diary	
	Display diary answers along with vitals, if diary questions were answered.

Scenarios of Use

<u>Input data into diary</u>

- Andy ate a big meal for dinner and uses the diary to input that information into the app. The next day, Andy eats a lighter meal for dinner and inputs that information into the app. Over time, Andy checks the diary to see what external factors are contributing to his sleeping patterns. Andy realizes that when he eats a lighter dinner he sleeps better throughout the night.
- Haley enjoys exercising almost every day. She likes to work out around 8pm every night, which is within 6 hours of going to sleep. Haley clicks on the "Fitness Exercise" section of the diary to input the data.

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Final Project Specifications
12/10/2018

General Description of Task Characteristics

This task is intended to be performed daily, to input additional information about factors during the day that may affect sleep. Users who choose to do this task will likely do so prior to sleeping. The task is a very short and simple survey of a few items that may affect sleep quality (caffeine consumption, stress levels, heavy meals, exercise prior to sleep, alcohol consumption). The user provides a yes/no answer to each of the questions.

The task is not mandatory but will provide more data for analyzing vitals, so users can understand what factors may be influencing sleep quality. Users will still get complete data on vitals and sleep scores whether they use this feature or not.

This task can only be done by the main user the device is tracking, but other users tracking the key user's vitals can view data on their diary input and how it connects to their sleep scores and vitals. Users can complete their diary from anywhere.

There is no training provided on diary use, and users learn how to do the task by visiting the page and quickly learning how to answer and submit their diary questions.

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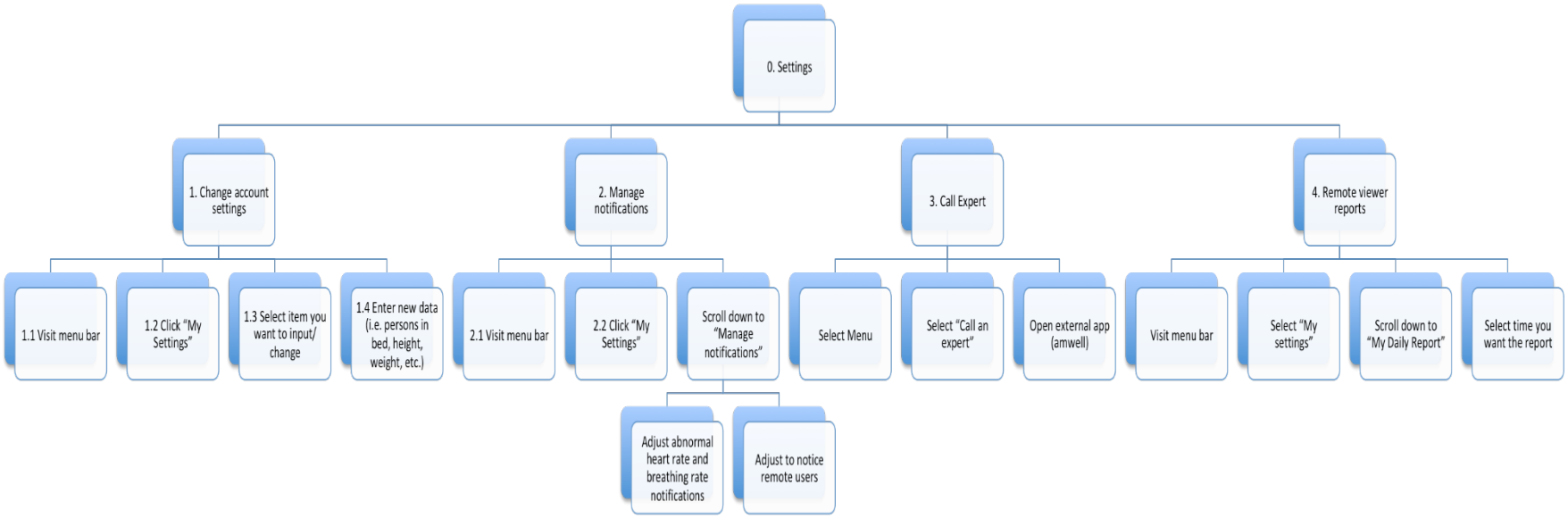
12/10/2018

Task 5: Changing Settings

Hierarchical Description



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12/10/2018

Essential Use Cases

CallExpert

USER INTENTION	SYSTEM RESPONSIBILITY
Contact an expert	
	Link user to external application for expert advice.

ChangeSettings

USER INTENTION	SYSTEM RESPONSIBILITY
Change account settings and develop reports	
	Allow users to access their use settings
Change setting(s) of interest	
	Display all settings and allow user to make edits.
Save changes	
	Save settings in system

Scenarios of Use

<u>Call an expert</u>

- Andy checks his health summary data on the app and realizes that his heart rate is abnormally high. He wants to call a health expert to make sure that everything is okay. He selects the main menu and then "Call an Expert" which continues to an external app provided by Amwell.

<u>Change account settings</u>

- Haley's email account recently got hacked. She wants all her data to be more secure, so she decides to change her password on the EarlySense app. She selects the main menu and clicks on "My Settings". Haley can change her password, update her name, and email account.
- Beth wants to configure a daily report on her son Max's sleep. She selects the main menu and clicks on "My Settings". She can configure a daily report and select the time of day she wants to receive the report. Beth chooses to receive a report at 8am everyday so that she can monitor Max's sleep patterns from the previous night.
- Andy has begun to sleep next to his wife again, but still wants to continue using the device to monitor his sleep. He selects the main menu and clicks on "My Settings". He goes to the section where you can change the number of people in the bed, and changes the value from 1 to 2, then saves.
- Deandra wants to be notified when her patient's heart rate is abnormal. She goes into "My Settings" and manages her notifications so that she will receive an alert if the patient has an abnormal heart rate while asleep.

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Final Project Specifications
12/10/2018

General Description of Task Characteristics

This task will mainly be performed after setting up the device but can be revisited briefly if the user needs to update data, such as weight and persons in bed. It can also be returned to so users can setup how their data is reported to other users who are connected to the device as well and manage alerts on abnormal vitals.

This task is not very complex, having the same degree of complexity as filling out any online form with basic information (age, weight, height, etc...). The page is structured as a variety of form inputs that are designed to fit the necessary data (e.g. date of birth allows you to select the month, year, and day from a popup calendar). This section also allows users to adjust units of measurement based on what they prefer (e.g. kg vs. lb.).

This task can be performed on the mobile application from anywhere. The settings that are tied to the device and data reports can only be managed by the key user who the device is tracking. The device does not train users to manage their settings. If users incorrectly enter this data, it may affect the quality of reports or advice the application gives to the user.

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Final Project Specifications
12/10/2018

Interface Design Decisions

Design Decision #1: Allow Users to Compare Dates Side-by-Side

Design Issue

In the current system, users can view their sleep data daily, comparing their sleep throughout the night. However, it is difficult to compare your sleep statistics across multiple days. Users take advantage of this app to monitor their sleep and identify patterns. The app is not conducive to any improvement in quality of sleep because users cannot monitor the changes in their sleep across time. The only functionality that the app provides for comparing statistics only displays sleep score and physical statistics in weekly or monthly timeframes (see: Figure 1).

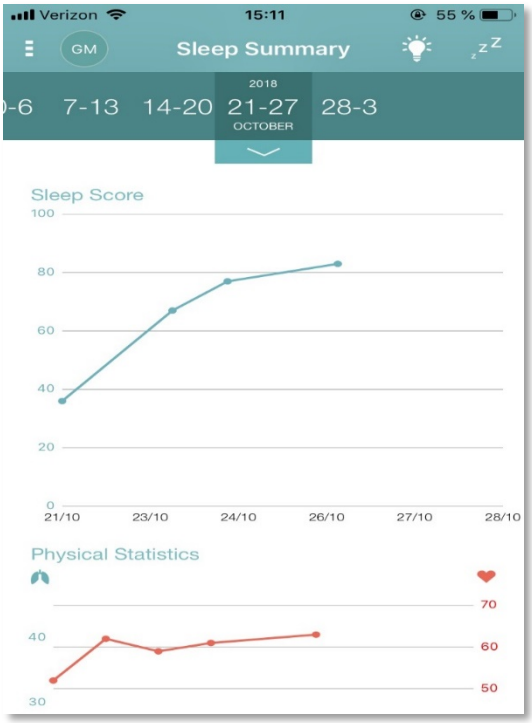

FIGURE 1: COMPARISON OF SLEEP SCORE AND PHYSICAL STATISTICS ACROSS A ONE-WEEK SPAN

Decision

To better serve the users, we want to create a comparison function across any custom range. We chose to implement this design decision because of human's natural tendency to compare. We are always striving to make sense of the world around us by identifying patterns[4]. Creating a way to compare sleep data across dates would aid users in identifying and understanding their sleep data. Additionally, this decision would minimize memory load by providing all relevant information in one place. Without this tool, users would have to flip between screens for two separate dates and try to remember their statistics. By placing the information all together, the user can focus on analyzing the data rather than memorizing their statistics.

Alternatives

When making this design decision we considering alternatives such as modifying the existing comparison tool but decided that enough new functionality was required to warrant a new portion of the app. Our comparison will look at all the sleep statistics/scores to provide a more holistic view of each night's sleep. The comparison will not just be graphs but changes to scores/metrics to better indicate improvements. We want to include these metrics to help users who are not as familiar with the statistics measured so they understand their impact on their sleep and health. For example, people may not understand that a higher heart rate is not necessarily better but through our metrics (rather than just a graph) higher heart rates will have lower scores.

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Final Project Specifications
12/10/2018

Design Decision #2: Provide Explanation of Metrics in Sleep Summary

Design Issue

The EarlySense Live tracks a multitude of statistics including stress level, REM sleep and heart rate. These metrics are presented to users to help them better understand their sleep and track and monitor their health. However, these metrics may be meaningless to users with no medical expertise. In order to correct this confusion. On the app, the user can only access the explanations of metrics through the Health Summary page (see: Figure 2). On this page, when users click a metric, they are taken to a new tab that provides expanded information (see: Figure 3). Users can learn more about heart rate, breathing rate, stress level and the sleep score. Through the sleep score, users are provided with information about the specific sleep statistics in a general summary page. We believe that users should be provided with information about each sleep statistic separately, so they can better understand what the EarlySense Live is tracking.

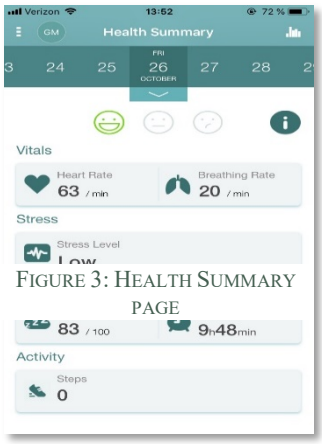

FIGURE 3: HEALTH SUMMARY PAGE

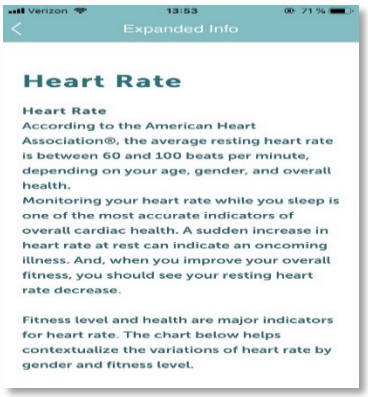

FIGURE 2: EXPANDED INFORMATION PAGE ON HEART RATE

Decision

We chose to implement a pop-up that is displayed only by user action: when a user clicks on a sleep metric, a popup explaining only that metric will appear. This will allow users to learn about the statistic without placing too much of a burden on their mental load. The user will be returned to the sleep summary page when they exit the popup. Additionally, instead of providing a chart with average sleep metrics per age (see: Figure 4), we want to compare the user's actual vitals to only their appropriate age range. This will make it easier for the user to compare their information to the average without having the sift through extraneous information.

FIGURE 4: COMPARISON SLEEP CHART BY AGE

Alternatives

We considered implementing a more robust but still separate information page. However, we decided this wasn't effective because users will not leave a screen in order to search for supporting information[7]. According to Tognazzini, "If the user cannot find it, it does not exist"[7]. The information page was too deeply buried in the application hierarchy to be helpful to users. Another alternative we considered was implementing pop-ups to provide information to the users when they began looking at the statistics (i.e. when they first downloaded and began to use the site: like a tutorial of the app functionality). We decided this would be too distracting for the user and did not allow users to explore this feature at their own leisure. According to Nielsen Norman Group, modal dialogues interrupt the user workflow and increase the cognitive load of the user[3].

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Final Project Specifications
12/10/2018

Design Decision #3: Modify Sleep Score Formula and Graphical Display

Design Issue

The current system calculates the user's "sleep score" based on several metrics (such as total sleep time, time to fall asleep and REM sleep) and displays the total score using half-circle charts (see: Figure 5). There are several issues with this display, a key issue being that people have trouble interpreting circular graphs because it is difficult to decipher angles[6]. In addition to this issue, the scoring is not very intuitive and does not seem to match with the display chart. For example, figure 5 shows that a sleep time score of 75 and a time to fall asleep score of -1 have corresponding sections on the semi-circle graph that are similar in size. Despite these issues, the current display is visually appealing, does not take too much space, and displays the total score in an easy to read location, so any modification to the display should try to retain those positive aspects.

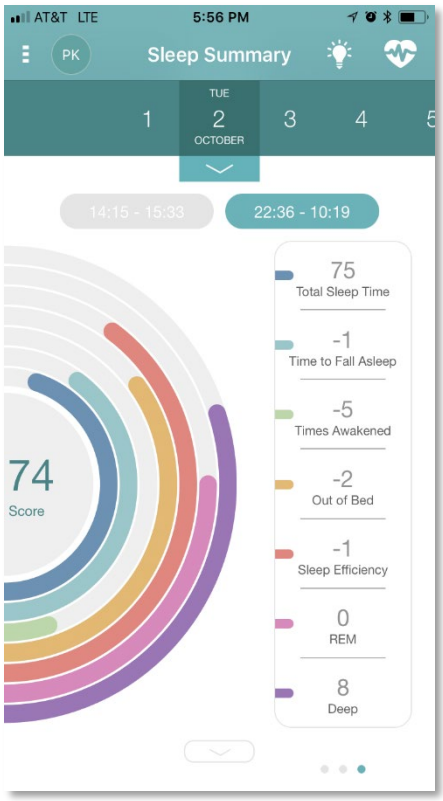


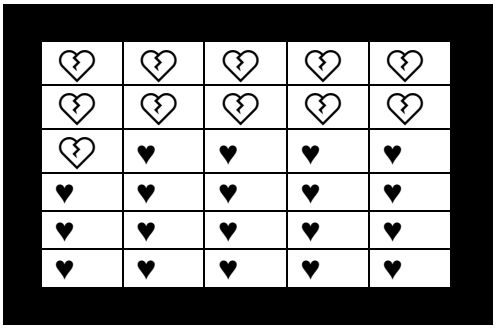
FIGURE 5: SLEEP SCORE DISPLAY AND POINTS CALCULATION

Decision

Our decision has two parts: (1) Modifying how sleep score is calculated, and (2) Modifying how the score is graphically displayed. The reason for modifying the sleep score first was in part to make it easier for users to understand, but also so there would be a more intuitive way to graphically display a total score with all metrics included. The problem with the current scoring is that it includes negative values, which is difficult to graphically display negative and positive values in a total score display. While the exact scoring would be best decided upon by medical consultants, the general scoring should be like a grading rubric, where each scoring metric may have a different weight based on their own criteria.
To display the score, we decided that a waffle chart would work best, because it could satisfy the following criteria:

- It will not take up too much space and will be aesthetically pleasing.
- Total percentage score could be displayed easily.
- Can display all metrics at the same time and their weighting.

The waffle chart display we will use still requires some testing, but we have an early prototype that should satisfy the above criteria (see: Figure 6). Our current prototype is a 5x6 grid to reduce space. The total percentage score could be easily displayed above the grid, as our prototype demonstrates. The main benefit of the waffle chart is easily displaying each metric together and their relative weight, which has been done through color-coding and use of different symbols (in this case, a heart for point scored, and a broken heart for points missed).



Metric	Points	Color
Total Sleep Time	8/10	
Time to Sleep	2/3	
Times Awakened	1/3	
Out of Bed	1/3	
Sleep Efficiency	2/5	
REM	3/3	
Deep Sleep	2/3	
Total	19/30	

FIGURE 6: SLEEP SCORE WAFFLE CHART 5X6 GRID WITH POINTS AND COLOR KEY

Alternatives

Several alternative displays were considered, most of which still required changing how scores were calculated. We rejected these alternatives because they could not satisfy some or all the criteria mentioned above.

- <u>Alternative 1: Horizontal Bar Chart</u>
  A Horizontal bar-chart could easily display the scores for each section without modification to the scoring system, as it could display negative values (see: Figure 7). One issue is that it takes a lot of horizontal space that most phone displays do not have. Another issue is that metrics with lower weighting are harder to see because the graph is skewed by the highest weighted item.

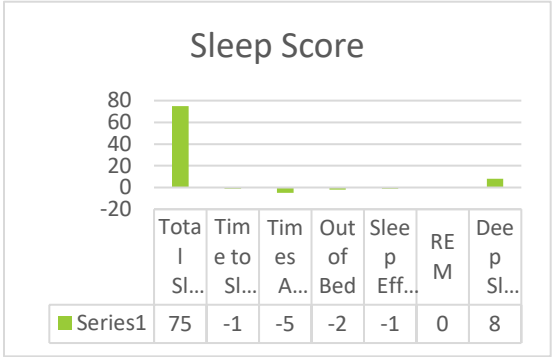


FIGURE 7: HORIZONTAL BAR CHART OF SLEEP SCORE

- <u>Alternative 2: Vertical Bar Chart</u>
  A vertical bar-chart could also rely on the original scoring method and does improve upon the issue of horizontal charts since it takes up more vertical than horizontal space (see: Figure 8). It still has the same issues as the horizontal chart where weightings are skewed.

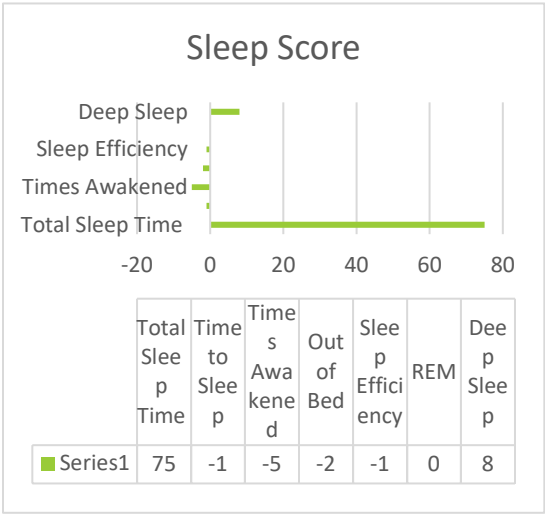


FIGURE 8: VERTICAL BAR CHART OF SLEEP SCORE

- <u>Alternative 3: Tree-Map</u>
  A tree-map would be compact like a waffle chart and be able to display relative weight of different items. It would however not be able to display the score out of each component, because they are designed to fill an entire grid 100%.

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Final Project Specifications
12/10/2018

Design Decision #4: Add an Expand Button to Interact with Charts

Design Issue

Currently, the user must use two fingers to pinch and zoom on graphs in the sleep summary page (see: Figure 9). One issue with this is that there is nothing to indicate that users should do so, and many may not discover that they can zoom in at all unless by accident. In addition to this, once a single graph is zoomed in on, all graphs on the page have horizontal scrolling enabled. This means that when a user touches the area of a graph, they will start scrolling horizontally on that graph, rather than vertically on the page. This introduces a problem where it becomes more difficult for the user to scroll up and down the page because they must put their fingers on the limited whitespace where no graph is present to do so, otherwise they are caught in the graph's scrolling span instead of the page's (see: Figure 10).

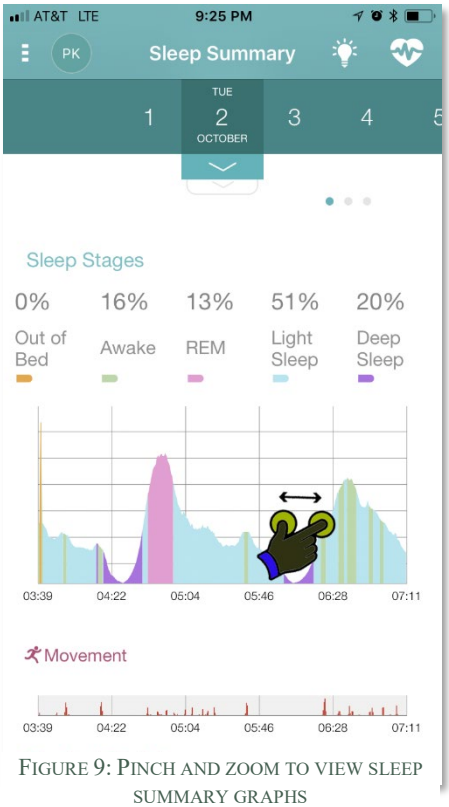

FIGURE 9: PINCH AND ZOOM TO VIEW SLEEP SUMMARY GRAPHS

Decision

To remedy this issue, we decided that instead of making the users use their fingers to scroll and zoom, each of the graphs remain static on the main page but will have an expand button in the top-right corner (see: Figure 11). Clicking this button will pop up an expanded graph that takes up most of the page and can be easily scrolled and zoomed in on. When the user no longer needs to view the graph, they can exit the pop-up.

Alternatives

One alternative was to only enable scrolling on the graph that the user zoomed in on instead of all graphs. This may not be as obstructive as the current design, but users may still get their fingers caught on that graph. It will also confuse some users who will be unsure why they can scroll across one graph and not the others.

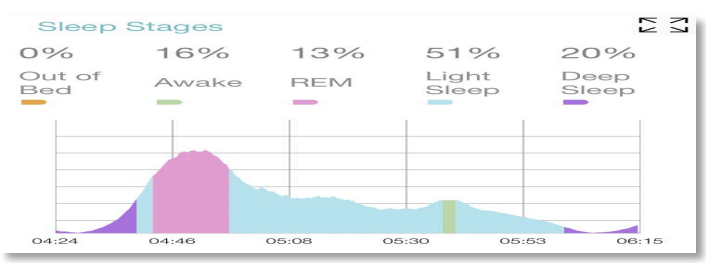

FIGURE 11: GRAPH DISPLAY WITH EXPAND BUTTON

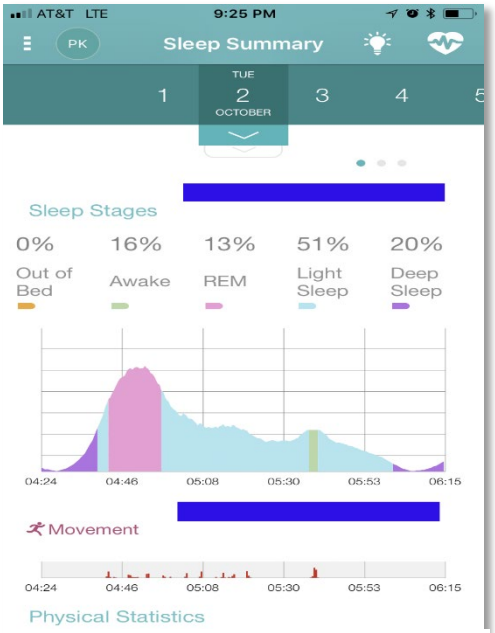

FIGURE 10: PAGE AFTER A GRAPH HAS BEEN ZOOMED IN ON. BLUE RECTANGLES INDICATE THE ONLY CLICKABLE AREA THAT A USER CAN SCROLL UP AND DOWN ON THE PAGE.

Design Decision #5: Updating the Homepage

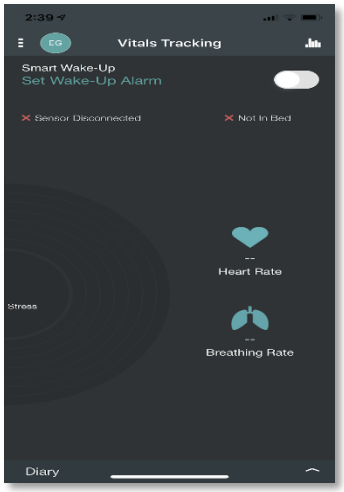

FIGURE 12: HOMEPAGE - SENSOR DISCONNECTED, NOT IN BED

Design Issue

In the current design, the homepage of the app looks very similar to the health and sleep summary page (see: Figure 12). This may cause confusion when the user is looking for their data. We think that the homepage of the app should be clear and useful. This page displays data using the same confusing half-circle graph, however, it is supposed to be displaying health data in real time. Considering that this app is mostly used right before bed, the display of real-time health data is not useful, as the user will be asleep. We suggest a re-design to the Homepage that makes sense to the user while providing information that's most useful.

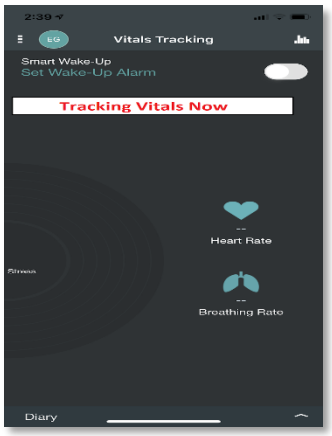

FIGURE 14: HOMEPAGE - TRACKING VITALS INDICATOR

Decision

The live vital tracking displays should be updated so that it is clear to the user when the sensor is disconnected. As pictured in figure 12, the "Sensor Disconnected" and "Not In bed" are quite small at the top of the page. We think that making these larger, as well as creating a helping suggestion for the user to connect the device, will make things easier for the user.

We think it is important that the user is notified when the device has started to live track their vitals. Besides the notifications saying, "Sensor Disconnected" and "Not in Bed", there is no way to notify the user that the device is tracking sleep. We suggest displaying the vitals live tracking once it is connected, to help the user make sure the device is working properly. This should be in an easy to read location, at the top of the page in a larger font (see: Figure 13). Our final recommendation for the homepage is the display of sleep summaries from the past several days. Currently, it is difficult to locate previous sleep cycles, so we suggest putting this information in a more easily accessible location. Since this app is used mostly for tracking sleep, we think the users should be able to compare sleep summaries side-by-side on the homepage (see: Figure 14). The user can then use this information to improve sleep.

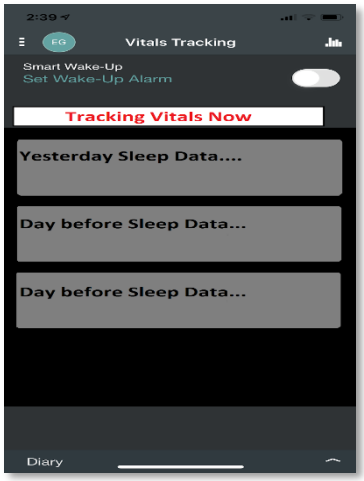

FIGURE 13: HOMEPAGE WITH LATEST SLEEP DATA

Alternatives

One alternative was to use the homepage space to display average vitals. The issue with this was that the purpose of the application is to see change over time and hopefully improvements, not aggregate data that will be skewed by older data points. Another option was to display graphs on the homepage to view changes across different days. The issue with this is that graphs can take more time to interpret, and require a lot of data to be useful, so they may not be appealing on a homepage to a new user.

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Final Project Specifications
12/10/2018

Design Decision #6: Display Sleep Information First on Metrics Sidebar

Design Issue

At first glance, the half-circle pie chart on the Sleep Summary page is confusing without knowing what colors relate to what part of the sleep score chart. This is because the sidebar first displays heart rate, breathing rate, and stress level vitals, instead of the sleep score elements (see: Figure 15). Only when the user scrolls to the right on the sidebar, to see the second display, will they see the metrics for the sleep score (see: Figure 16). Finally, another scroll to the right will show them the breakdown of those metrics that add to the total sleep score (see: Figure 17). Our design decision 3 discussed how the scoring and display should be changed to be more intuitive, but to make that possible, users must first be able to see the scoring metrics beside the chart without having to explore anything on the page.

FIGURE 15: SLEEP SUMMARY - FIRST SIDEBAR

FIGURE 16: SLEEP SUMMARY - SECOND SIDEBAR

Decision

The sleep score data should be the first displayed in the sidebar so that the user can make sense of the graph (see: Figure 17). Next, should be the sleep information, such as amount of sleep (see: Figure 16). The last page should be the heart rate, breathing rate, and stress level information (see: Figure 15).
Also, the current sidebar does not easily display the information, or show more information is available. The sidebar should indicate that it is interactive and can be used to scroll to different information. We suggest adding the slider buttons at the top of the sidebar to indicate more scrolling is available. It is important that the user can access all the information on the page.

Alternatives

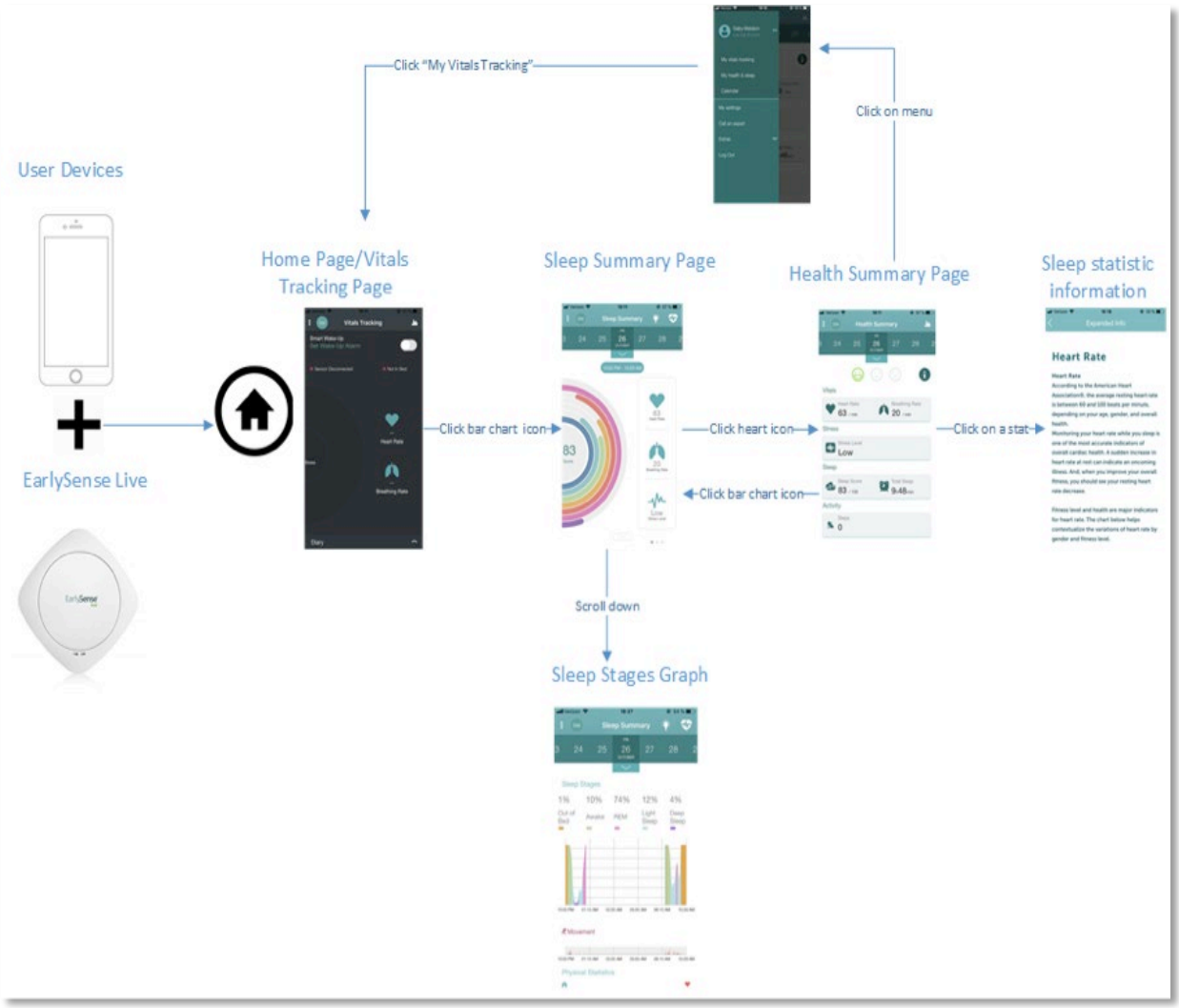
One alternative would have been to display the sleep information first, then the scoring information, and finally the vitals. While it may be useful to first see the values for each metric, users will still be confused about how the sleep score was calculated. Another alternative would be to display all or some of this information simultaneously. It would be possible to display the vitals information below the sleep score chart, but to display both the sleep score points and the actual measurements themselves simultaneously would cause a lot of clutter on small screens. An option to have the scores appear as a popup when clicking on one of the measurements was also considered, but this would also require users to be confused for a while until they find that the option is available, which is not ideal.

FIGURE 17: SLEEP SUMMARY - THIRD SIDEBAR

Interface Design Description

State Transition Diagrams

Current Application:
This current application has some areas where navigation is not very intuitive and takes unnecessary extra steps. For example, users must click a bar chart icon to reach the sleep summary page, though this icon has little relation to what is displayed when you first see the page. Additionally, users cannot click on the various metrics displayed on the sleep summary page to find explanations about them. They just instead click on the heartbeat icon from the sleep summary page to find the health summary page where they can click on metrics and pull up an expanded information page. This heartbeat icon is also not present on the homepage, which means users must go through several steps to reach it.



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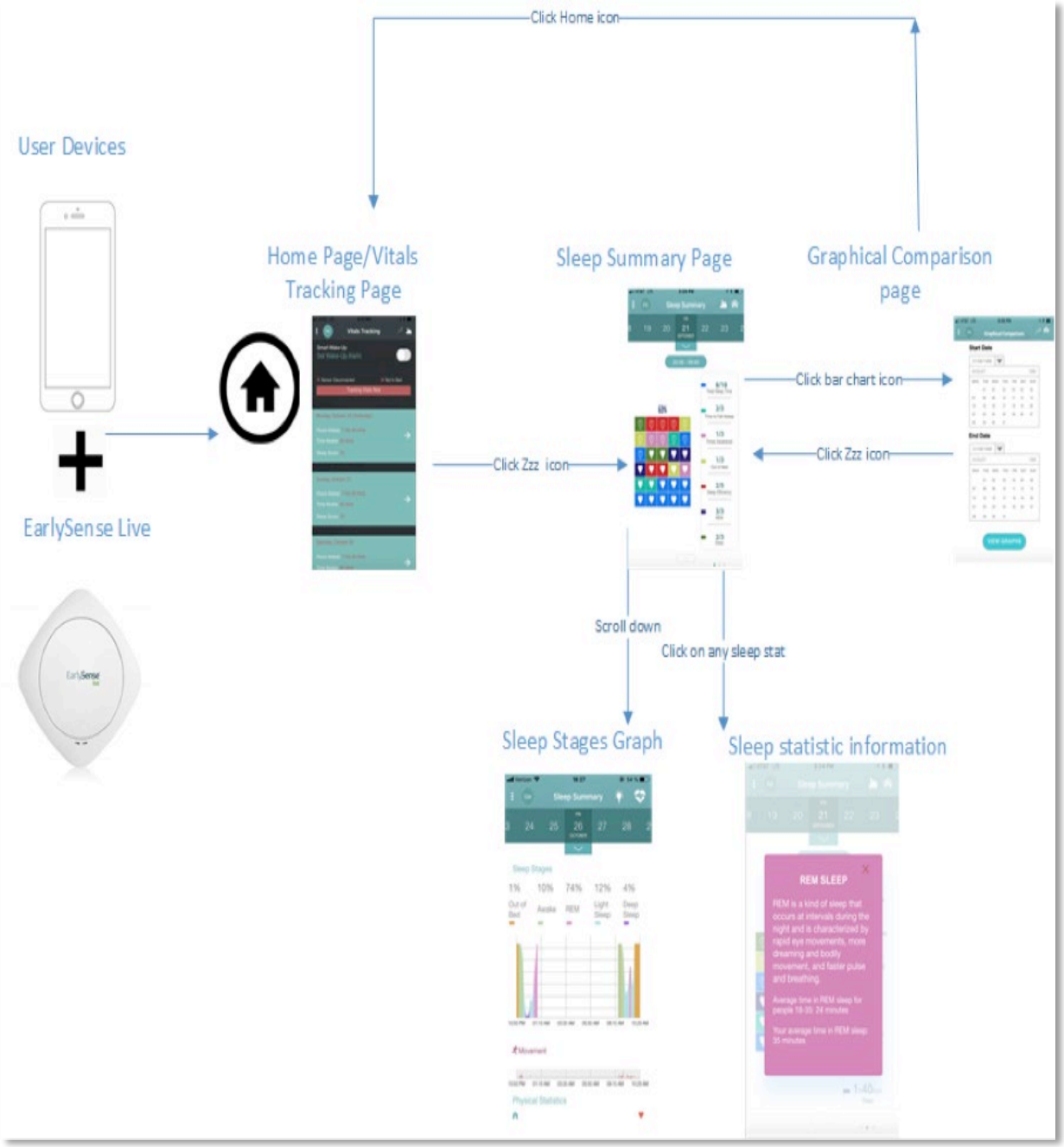
Redesigned application:
With our design decisions, we aimed to simplify the system architecture. In the current app, certain pages, such as the Health summary page or the Sleep Statistic information page, cannot be accessed from the homepage and the user must navigate to secondary pages in order to access them. To remedy this, we created icons (located in the top right corner) that lead you to all three of the main pages. This allows simpler navigation and the elimination of any hidden pages.



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Prototype Design Decisions

Our prototype of the EarlySense Live device reflects several design critiques with the application that the group previously identified. The first critique being that there was no way of comparing various sleep data with a custom range. We tried to fix this in our prototype by having a graphical comparison where the user can select the dates they wish to compare. Another critique of the application was the explanations and definitions of certain keywords. Our prototype has a pop-up window that explains the key word when the user clicks on the word. This way the user gets the relevant information easily and quickly. This pop-up window also allows the user to see how their current vital compares to the national average.

Another big issue with the app was the circular graph that represented the sleep score data. This graph proved to be confusing and hard to decipher. We changed this graph to a waffle chart in hopes of better representing the sleep score data. We also changed the way the scores were tabulated as the previous scores had too much variation across metrics and some could have negative values while others could not, which was confusing. We also wanted to change the first sidebar display of the heart rate, breathing rate, and low stress level to the last sidebar page and have the breakdown of the statistics on the first sidebar page.

While viewing the health data graph on the app, the view scrolling feature is not clear. In our prototype we have made it clear that the user can scroll with two fingers to closer view their data.

The last major change was the homepage. The current homepage does not provide information of value. We have decided to change the homepage to show previous sleep summaries with arrows that allow the user to see more of their sleeping data. We believe that these changes improve the application's usability and functionality, allowing for a better experience of the product.

The above changes deal with what we identified as the six most problematic aspects of the current design. However, there were several other functions of this application that have room for improvement but analyzing and prototyping those changes were outside the scope and requirements of this project. These areas that have no implementation in the prototype include:

- Diary function on the homepage.
- Alarm clock on the homepage.
- Menu and settings

Our prototype can be viewed and interacted with on the following link: goo.gl/gE1VPg

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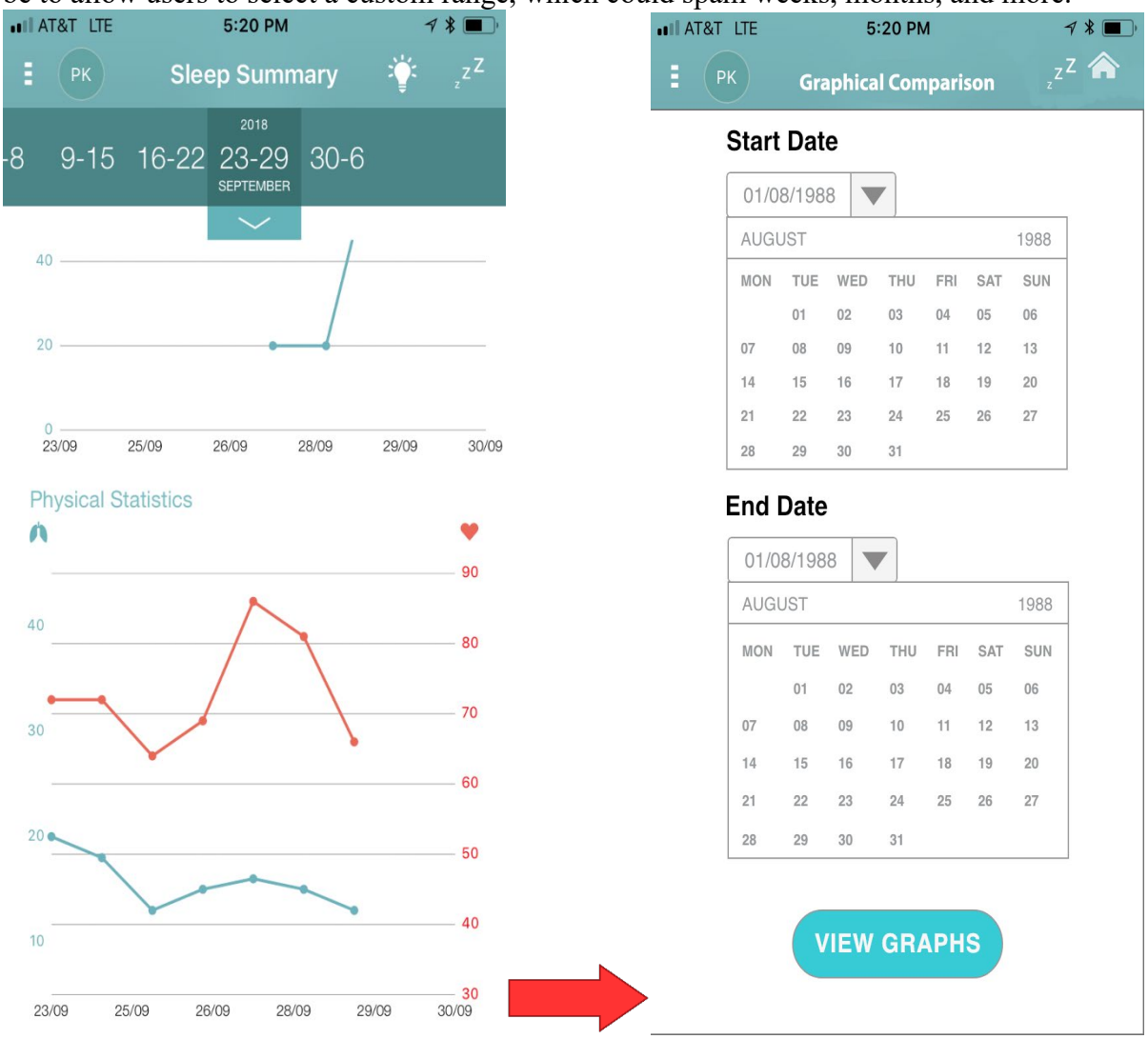
Prototype Changes

We have annotated screenshots of the old application and prototype for comparison. The following is our annotation key:
Red arrows: indicate separation between current application and our prototype
Black arrows: indicate movement between pages, either within the current application or within our prototype.

Changing dates across a custom range

In the current system users can only view dates across a weekly range on the sleep summary (as shown in the first image below, users can swap between different weeks such as the week of the 16th of September or the week of the 23rd of September). Our proposal for the new system would be to allow users to select a custom range, which could spam weeks, months, and more.



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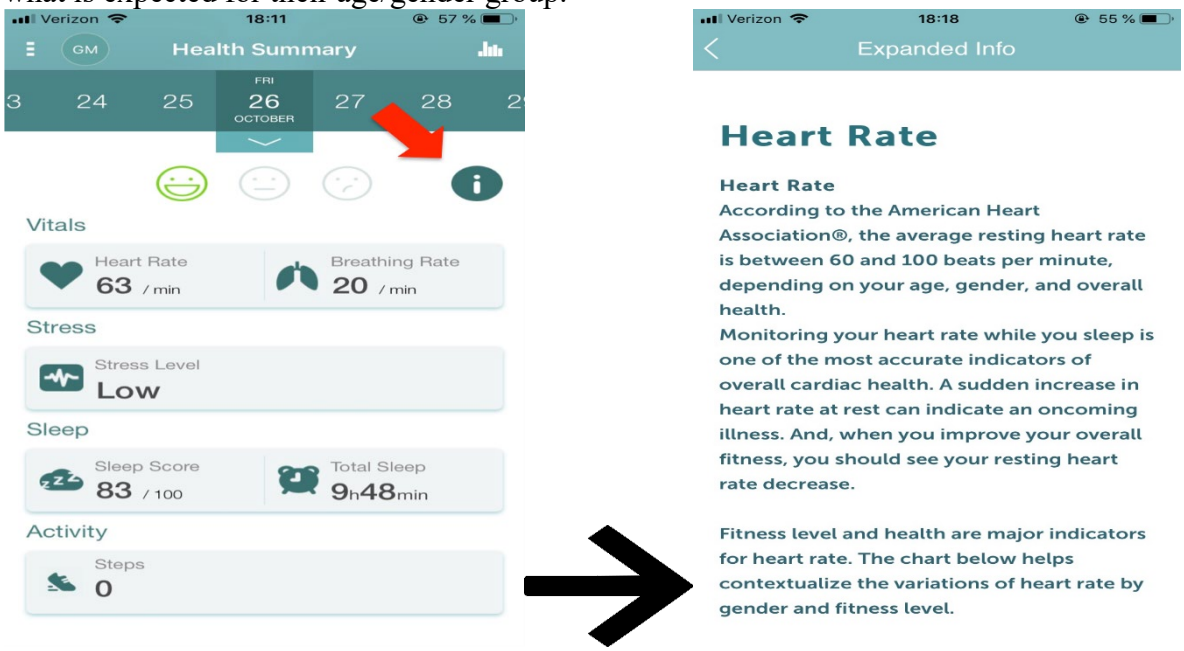
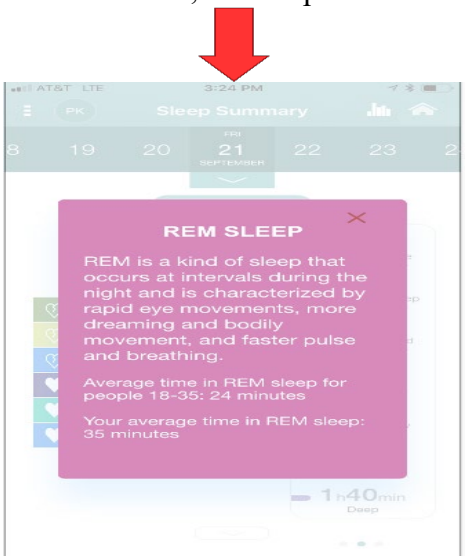
Sleep and vital metrics explanation pop-ups

The current system would only display on-click pop-ups for information on certain sleep or vital information in a “health summary” page, rather than on the “sleep summary” page where those metrics were displayed first anyways. These popups would take the user to an “expanded info” page that users often had to scroll down through a non-mobile friendly page to find a table to compare their information to. The proposed system in our prototype has these pop-ups appear on the “sleep summary” page where users will spend their most time looking at, and they will display concise information that allow users to simply compare their values to the average values or what is expected for their age/gender group.



When the (i) button is selected, the “Expanded Info” page is opened



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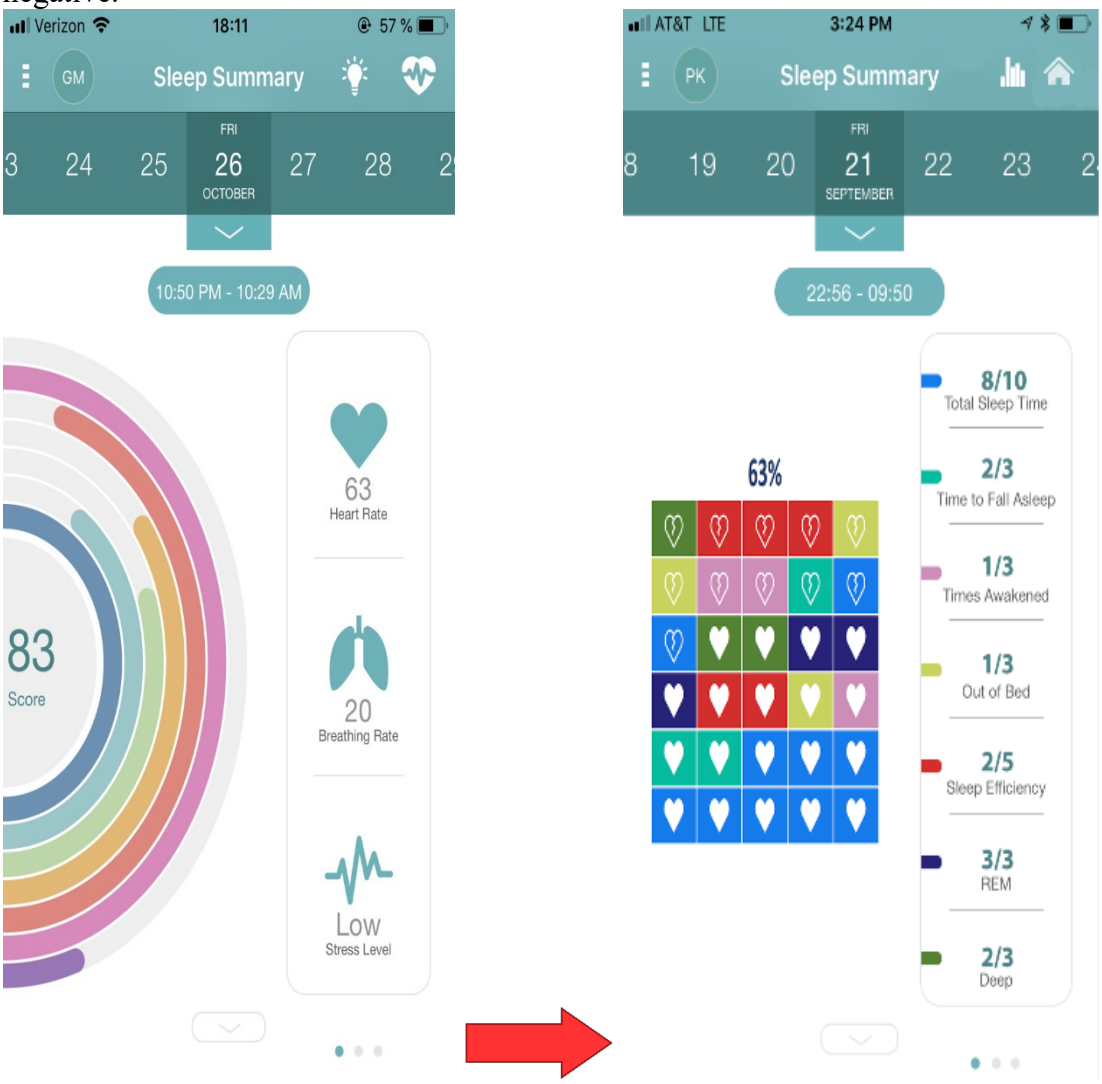
Displaying sleep statistics on first side-bar

In the current system, the sleep summary page has a side-bar on the right side of the page, with 3 parts: (1) basic vitals (heart rate, breathing, stress), (2) sleep metrics, and (3) sleep score components. This order of information displayed made it difficult for users to understand the sleep score graph, so our proposed system in the prototype has re-ordered it such that the scores are displayed first, then sleep metrics, and finally basic vitals. The scoring itself was also changed to better reflect what the new waffle chart graph displays. The scoring would be displayed out of a total for each metric, rather than a score number that may be positive or negative.



Change was made from displaying Heart rate, breathing rate and low stress level to displaying the breakdown of the statistics on the 1st sidebar page. The sidebar displayed in the image on the left is the third sidebar display in the prototype

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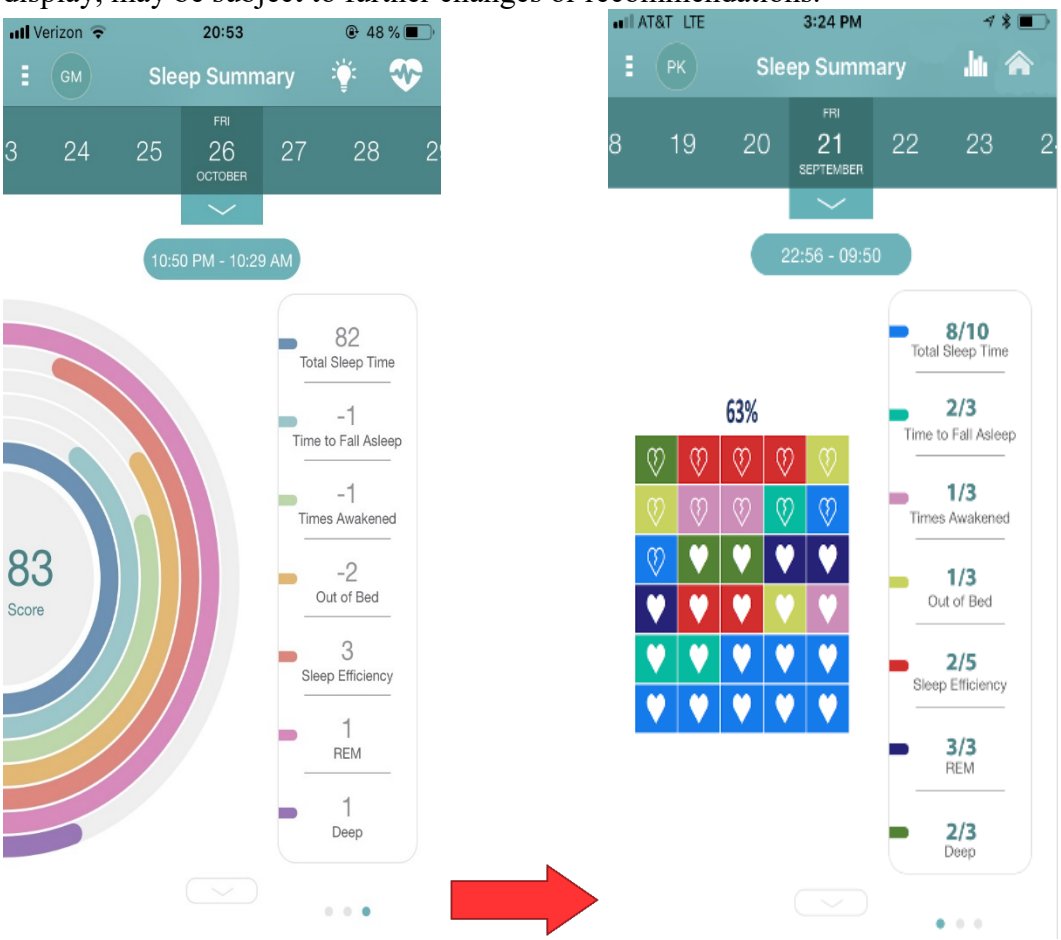
Modifying sleep score graphical display

As discussed, the current system used a circular graphic display to show the sleep score for the user on a particular day. This display was not very intuitive to understand, especially because the scoring for each metric was not consistent. For example, sleep time could be scored very high at 82 while time to fall asleep was on a smaller range and could receive a negative score, such as -1. On the graph, it would appear as if the sleep time score of 82 and the time to fall asleep score of -1 were close, despite the numbers being vastly different. Our prototype changed the scoring, as discussed earlier, as well as changed the circular graph to a waffle-chart display. On this waffle chart, each metric is assigned a color that appears on the graph and the side-bar (e.g. blue for total sleep time). If the user scores, for example, 8 out of 10 on total sleep time, the waffle chart will show 8 hearts with a blue background, and 2 broken hearts with a blue background. This display will help show users how many points they are missing and in which metric, so they could better improve their sleep.
The current iteration of having the broken hearts on top, as well as using this grouping of colors, was chosen prior to usability testing, so these choices, as well as the overall new graphical display, may be subject to further changes or recommendations.



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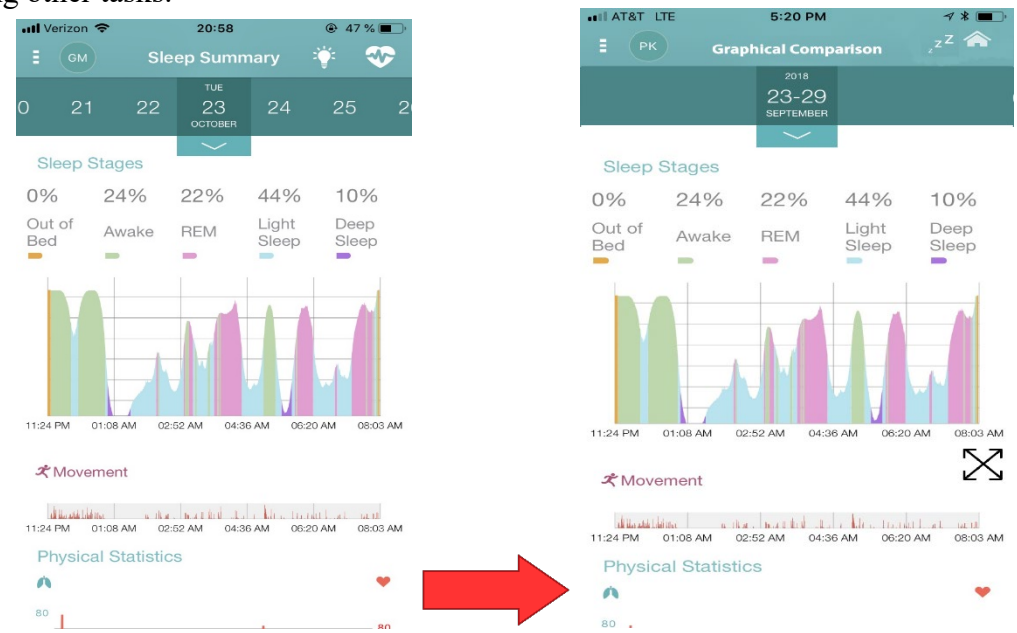
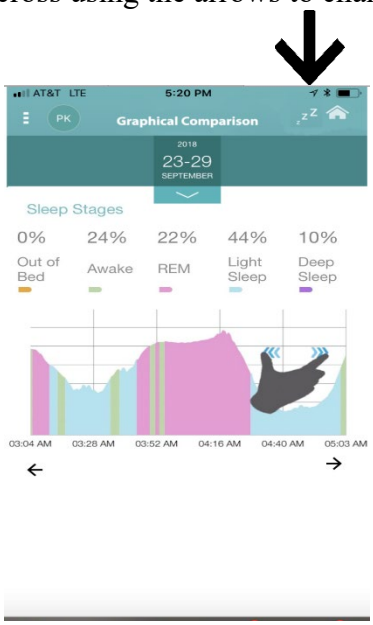
Zoom feature on graphs

On the current system, users can pinch of pull a graph with two fingers in order to zoom on it. The problem with this is that once they zoom on a graph, the page enables horizontal scrolling across all graphs, and when users try to vertical scroll, they may get caught in the horizontal scrolling section of a graph and have trouble navigating the page. The prototype proposes to instead use an expand button on graphs that will take the user to a different page where they can do the zooming in and scrolling on graphs. This will allow users for full control of graphs while not disrupting other tasks.



When the user clicks the expand button it brings them to a new page where they can then zoom in further or scroll across using the arrows to change the time of night



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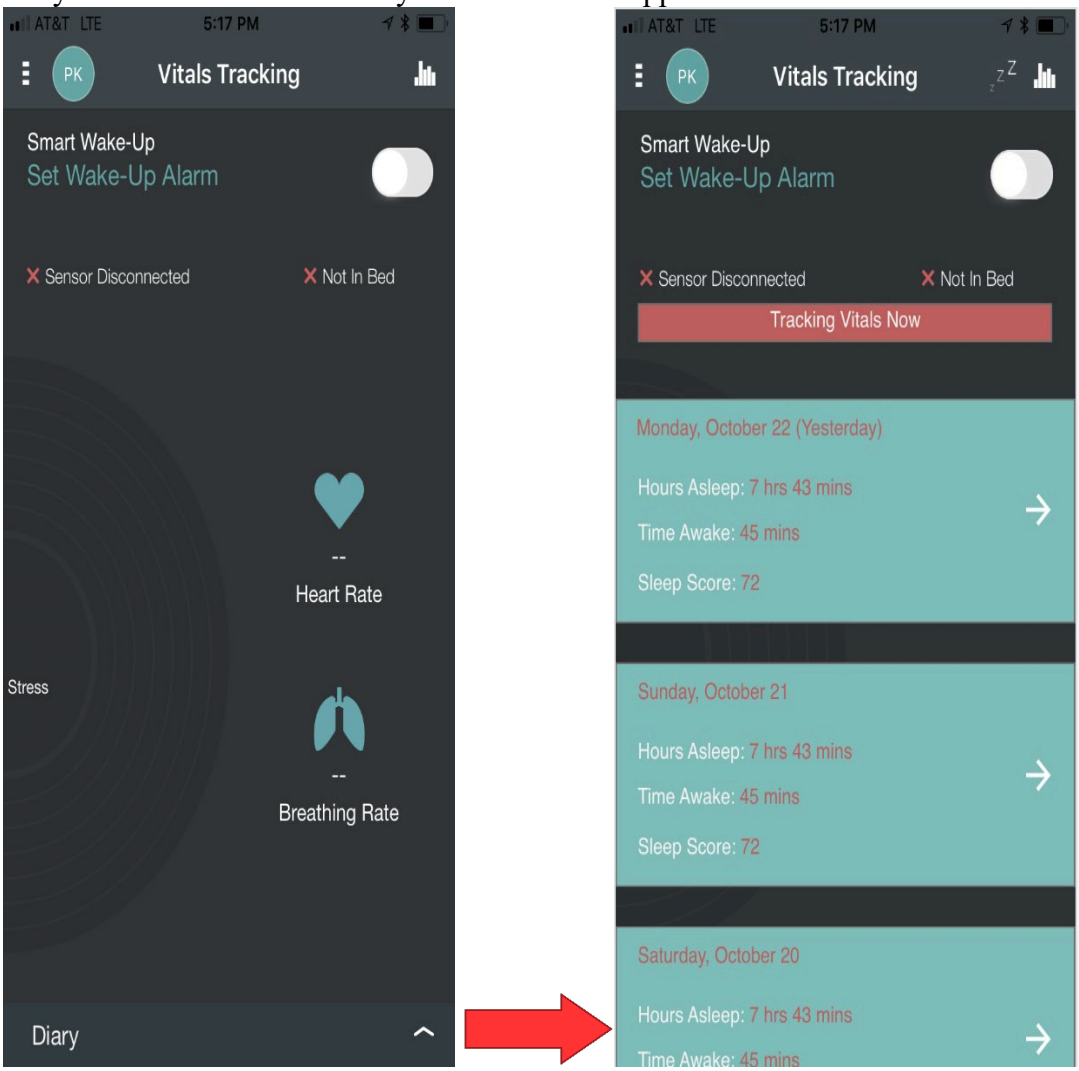
Updated Homepage

The current system's homepage indicates to users whether they are connected to the device and if it is tracking their sleep, while also showing live tracking results. These live tracking results are not useful to at-home users who are sleeping while the tracking is going on, so they are unable to view it.
Our prototype has a modified homepage, where the display for whether the system is tracking sleep and vitals remains (and is also more prominent), but instead of a life tracking display, it will display information on sleep for past days. Each of these past days can be clicked on to view further information on the sleep metrics and vitals tracked on that day, including a graphical display.
As mentioned earlier, changes to the diary system and alarm system were not proposed in this proposal, despite a few more minor issues were encountered with them. However, for the scope of this project, we decided to limit the design decisions to more essential cases of use, and the diary and alarm were secondary features for this application.



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Usability Inspection

Testing Script

1. **Greeting – "**Thank you for coming to our study today. My name is [name], and I'll be working with you on your study today. At times, I will be reading directly from this script to ensure that my instructions to you are the same as to other participants in the study."
2. **Privacy statement -** "Your work today will help us evaluate the system and our design considerations. Your feedback will be anonymous and no personal information will be collected as part of this test. You can choose, at any point in the study, to stop your involvement and halt the continuation of the rest of the test. You will have the choice both during and after the study to keep or discard your feedback"
3. **Introduction to EarlySense Live – "**This application is used in conjunction with a physical sensor device that is placed underneath your mattress. The device analyzes sleep cycles and monitors health while the user sleeps. EarlySense was originally created to better support general care patients during their hospital stays but today, it is being used and marketed outside of hospitals to health-conscious adults, parents of small children and family members of senior citizens."

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4. **Tasks for original system**- *Ask the user to go through the tasks on the CURRENT APPLICATION*
    - First explain the task and answer any questions the user may have
    - Explain the think aloud process
        - Ask them to explain what they are thinking and feeling as they navigate around the app. Encourage them to say what is helpful or not helpful in terms of completing the task and express their frustrations
        - Have the user begin the task and start the timer
            - Give users a maximum time of 2 minutes per task
            - Keep notes on user's feedbacks and interaction with the application
        - Once the user finishes a task, ask them to share their overall feedback
        - Repeat for the rest of the tasks
5. **Post-task -** Ask for any additional feedback after the user has completed all the tasks on the original system

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6. **Tasks for new system -** Ask the user to go through the tasks on the prototype
7. **Post-task -** Ask for any additional feedback after the user has completed all the tasks on the prototype
    - Focus on differences between the systems and if the prototype improved it.
8. **Closing -** Thank the user for their time and confirm that it is still okay to use their feedback for the project

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Class Project Documentation
12/10/2018

Task List

Task List
1. **Task 1 – Homepage:** View yesterday's statistics of sleep information from the homepage. 2. **Task 2 – Graph Comparisons:** Compare your sleep across 2 days, 3 days, and one week. 3. **Task 3 – Information Popup:** Navigate to the sleep summary and find information that explains what REM sleep is. Then return to their sleep summary page. 4. **Task 4 – Sleep Information:** Identify how long you spent in REM sleep. 5. **Task 5 – Return to homepage:** Navigate back to the home page • (if user does not remember what the home page is, moderator can prompt them by saying it is the "Vitals tracking page") 6. **Task 6 – Sleep Score:** Show users the sleep summary page and ask them what they think of the graph. Does the graph adequately explain the sleep score?

User Analysis Findings

Participant 1: (Color-blind individual)

Current System	Prototype
Task 1 – Homepage: View yesterday's statistics of sleep information from the homepage.	
Steps Taken: - Clicked on menu bar, expected it to be on the first page. - Navigated to the calendar to find information from the previous day Feedback: - "have something in main menu to show definitions. Like vocab/lookup tab would be helpful"	Steps Taken: - Clicked on "Monday, October 22 (Yesterday)" - Viewed graphs and statistics. - Clicked the "x" button Feedback: - "I think this homepage is more useful" - "I'd like the terms to be explained (REM, Deep sleep, etc...)
Task 2 – Graph Comparisons: Compare your sleep across 2 days, 3 days, and one week.	
Steps Taken: - Clicked on menu - Clicked "extras" - Went to sleep summary page, took a moment before scrolling down to find graphs. - Flipped between dates on sleep summary page, comparing graphs to one another. Feedback: - "the page didn't show me that you can scroll down"	Steps Taken: - Clicked on graph symbol in top-right - Clicked "view graphs" - Clicked the expand button - Scrolled on graph, then exited. Feedback: - "This was easier to use, I can pick the dates I want" - "But it would be easier to tell how well it works if the calendar was actually functional, but I think it makes more sense"

- "I don't really understand what the numbers under physical statistics are" - "have some kind of stat tracker that shows graphs side-by-side"	- "the graph popups make more sense here, no scrolling down to find them"
Task 3 – Information Popup: Navigate to the sleep summary and find information that explains what REM sleep is. Then return to their sleep summary page.	
Steps Taken: - Clicked on REM sleep in sidebar on sleep summary page, didn't find anything. - Clicked on menu → extras. - Gave up Feedback: - "I'm not sure where it is, sorry"	Steps Taken: - Clicked on the "zzz" icon. - Clicked on "rem sleep", viewed popup Feedback: - "The new icon makes more sense" - "This was what I was trying to do with the old app that didn't work"
Task 4 – Sleep Information: Identify how long you spent in REM sleep	
Steps Taken: - Clicked on menu - Clicked bar graph icon in top right - Scrolled to rem sleep in side-bar - Read the value Feedback: - "I think this was okay, but I can't really see what that means or if it's good or not"	Steps Taken: - Exited the opened popup. - Read the value for REM sleep Feedback: - "I think it's a lot better that I can compare what I got to the information in this popup"
Task 5 – Return to homepage: Navigate back to the home page	
Steps Taken: - Clicked on menu - Clicked on user's name. - Clicked on menu again, then "my health and sleep" - Gave up Feedback: - "There isn't any home button or something like it"	Steps Taken: - Clicked on house icon in top-right Feedback: - "this was easier to do, but I think I should also get to it by clicking on the profile picture thing"
Task 6 – Sleep Score: Show users the sleep summary page and ask them what they think of the graph. Does the graph adequately explain the sleep score?	
Feedback: - "the graph is confusing" - "It's hard to tell the different colors apart, being color-blind"	Feedback: - "I think this makes more sense, but the colors are still a bit of a problem for me. Especially teal and green."

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12/10/2018

Participant 2:

Current System	Prototype
Task 1 – Homepage: View yesterday's statistics of sleep information from the homepage.	
Steps Taken: - Clicked on menu - Clicked on bar graph icon - Clicked on day at the top of the bar to the previous day. Feedback: - "should be able to select time of day, along with different filters, so you can see data that matters to you."	Steps Taken: - Clicked on "Monday, October 22 (Yesterday)" - Viewed graphs and statistics. - Clicked the "x" button Feedback: - "This was a lot easier" - "I think the other homepage didn't really have anything on it"
Task 2 – Graph Comparisons: Compare your sleep across 2 days, 3 days, and one week.	
Steps Taken: - Clicked on menu - Clicked on bar graph icon - Gave up Feedback: - "It shouldn't take me more than 3 taps to find something and then not find it"	Steps Taken: - Clicked on graph symbol in top-right - Clicked "view graphs" Feedback: - "That took me a few seconds to find it, I like that."
Task 3 – Information Popup: Navigate to the sleep summary and find information that explains what REM sleep is. Then return to their sleep summary page.	
Steps Taken: - Clicked on menu - clicked on bar graph icon - clicked on day at top of the page. - Clicked on heartbeat icon - Didn't see anything on health summary page for rem sleep. - Gave up. Feedback: - "I'm not sure you can do that"	Steps Taken: - Clicked on the "zzz" icon. - Clicked on "rem sleep", viewed popup Feedback: - "The last time these sections on the side-bar weren't here before, is that new?" - "I wouldn't have known you can scroll through this to see. It's easier to just have it in front of you first"
Task 4 – Sleep Information: Identify how long you spent in REM sleep	
Steps Taken: - Clicked on menu - clicked on bar graph icon - clicked on day at top of the page. - Gave up. Feedback: - "I expected it to be somewhere like on the chart maybe but it's not"	Steps Taken: - Exited the opened popup. - Read the value for REM sleep - Opened the popup again Feedback: - "This popup is a lot better. I can see what my sleep was on it. Easier to compare when it's all in front of you"
Task 5 – Return to homepage: Navigate back to the home page	
Steps Taken:	Steps Taken:

- Clicked on menu - Clicked away from menu - Asked if the sleep summary page is the homepage - Gave up Feedback: - "Is this not the homepage? There is nothing that says it's the homepage"	- Clicked on house icon in the top-right Feedback: - "That makes a lot more sense, and the homepage itself is actually useful so I can have a reason to go back to it."
Task 6 – Sleep Score: Show users the sleep summary page and ask them what they think of the graph. Does the graph adequately explain the sleep score?	
Feedback: - "I don't understand this, what do all the bars mean?" - "I should be able to click on this and view stuff like my REM or anything else"	Feedback: - "It's a bit better than the original" - "Are there any helpful hints so I can improve my sleep score better?" - "I don't get the broken hearts, maybe just don't include them and only have the ones you received instead?"

Participant 3:

Current System	Prototype
Task 1 – Homepage: View yesterday's statistics of sleep information from the homepage.	
Steps Taken: - Clicked on menu - Clicked on bar graph icon - Clicked on heartbeat icon - Gave up Feedback: - "I thought the graph should take you to graphs with each day or something."	Steps Taken: - Clicked on "Monday, October 22 (Yesterday)" - Viewed graphs and statistics. - Clicked the "x" button Feedback: - "This makes more sense, it's right in front of you"
Task 2 – Graph Comparisons: Compare your sleep across 2 days, 3 days, and one week.	
Steps Taken: - Clicked on menu - Clicked on bar graph icon - Tapped on circle sleep score graph. - Gave up Feedback: - "I really don't know where I'm supposed to find this."	Steps Taken: - Clicked on graph symbol in top-right - Clicked "view graphs" - Clicked expand button. Feedback: - "The icon takes you to where it should go, with actual graphs."
Task 3 – Information Popup: Navigate to the sleep summary and find information that explains what REM sleep is. Then return to their sleep summary page.	
Steps Taken: - Clicked on menu - clicked on bar graph icon	Steps Taken: - Clicked on the "zzz" icon. - Clicked on "rem sleep", viewed popup

- clicked on heartbeat icon - clicked on "sleep score" - Scrolled down and viewed table Feedback: - "This table is horrible, it doesn't even fit the page." - "Why can't I compare what I got in REM sleep to this easily?"	Feedback: - "This was easier to find, didn't have to scroll to it." - "No ugly table with everything in it. This is a lot simpler and easier for people to read and understand." - "Maybe you should put a link for more information that is missing from this?"
Task 4 – Sleep Information: Identify how long you spent in REM sleep	
Steps Taken: - Clicked on menu - clicked on bar graph icon - clicked buttons under side-bar, found sleep information. - Read out value for REM sleep. Feedback: - "I barely noticed this could scroll through, the buttons are small"	Steps Taken: - Exited the opened popup. - Read the value for REM sleep Feedback: - "It's right in front of you when you open the page. This is what I should see first, not the heartrate stuff. It's a sleep application, right?"
Task 5 – Return to homepage: Navigate back to the home page	
Steps Taken: - Clicked on bar graph icon - Clicked on profile name icon - Clicked on menu - Clicked on "my vitals tracking". Feedback: - "This is the homepage, right? There's not much going on here" - "why doesn't it just say it's the homepage?"	Steps Taken: - Clicked on house icon in the top-right Feedback: - "The home icon makes it more obvious, and it's always there, which is good."
Task 6 – Sleep Score: Show users the sleep summary page and ask them what they think of the graph. Does the graph adequately explain the sleep score?	
Feedback: - "It starts to make sense when you actually see the sidebar but if I didn't scroll, I wouldn't have found this." - "Why is sleep time's score so high and others are tiny?"	Feedback: - "The other chart is prettier, but I guess this could look better later" - "This one makes more sense. The scores with total values makes a whole lot more sense with it.

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Class Project Documentation
12/10/2018

Participant 4:

Current System	Prototype
Task 1 – Homepage: View yesterday's statistics of sleep information from the homepage.	
Steps Taken: - Clicked on menu - Clicked on bar graph icon - Clicked on day at the top of the bar to the previous day. Feedback: - "It's not on the homepage though, but I found something." - **"**Was that actually the homepage? It doesn't really look like one"	Steps Taken: - Clicked on "Monday, October 22 (Yesterday)" - Viewed graphs and statistics. Feedback: - "This is actually on the homepage, it's more useful."
Task 2 – Graph Comparisons: Compare your sleep across 2 days, 3 days, and one week.	
Steps Taken: - Clicked on menu - Clicked on bar graph icon - Clicked on a day at the top of the bar, scrolled down. - Clicked on another day at the top of the bar, scrolled down. Feedback: - "I can find individual days, but not really compare them except in my head, which is really hard to do mentally."	Steps Taken: - Clicked on graph symbol in top-right - Clicked "view graphs" - Clicked expand button. Feedback: - "So, these graphs should show you a span across the dates you select, right? This is so much easier" - "I like just choosing a date yourself, not scrolling through a bunch of dates"
Task 3 – Information Popup: Navigate to the sleep summary and find information that explains what REM sleep is. Then return to their sleep summary page.	
Steps Taken: - Clicked on menu - clicked on bar graph icon - clicked on heartbeat icon - clicked on the bar graph icon again - Gave up Feedback: - "I can see stuff for heartbeat but not REM." - **"**It should be easier to find sleep information, but I see a lot of other non-sleep stuff."	Steps Taken: - Clicked on the "zzz" icon. - Clicked on "rem sleep", viewed popup Feedback: - "I didn't see that this bar would have this information. Didn't look like you could scroll through it" - "It makes more sense that it's right in front of you now when you open the page, so you can just click it, but this sidebar should be more obvious to scroll."
Task 4 – Sleep Information: Identify how long you spent in REM sleep	
Steps Taken: - clicked on bar graph icon	Steps Taken: - Exited the opened popup. - Read the value for REM sleep

- clicked buttons under side-bar, found sleep information. - Read out value for REM sleep. Feedback: - "It took me a moment to realize I could scroll on this."	Feedback: - "I like that this matches with the popup. It's all in the same place instead of on separate pages or hard to find."
Task 5 – Return to homepage: Navigate back to the home page	
Steps Taken: - Clicked on bar graph icon - Clicked on menu - Gave up Feedback: - "There's no home button or anything like it."	Steps Taken: - Clicked on house icon in the top-right Feedback: - "I knew from the very beginning when I opened this that I could find the homepage just clicking that button"
Task 6 – Sleep Score: Show users the sleep summary page and ask them what they think of the graph. Does the graph adequately explain the sleep score?	
Feedback: - "I like the way it looks but don't get it." - "The values don't match at all. This one [the sleep time] is 75 and this other one [time to fall asleep] is -1, but the graph doesn't show it going negative or anything."	Feedback: - "I think this makes more sense, but still takes time to understand." - "I think all the hearts with the same color should be together, instead of stacked at the top with broken hearts." - "Having the total scores for each metric really helps understand this."

Evaluation

We identified some key strengths and weaknesses based on our usability analysis, presentation feedback, and understanding of design principles.

Strengths:

- The new popup feature for definitions of metrics is much easier to locate and read.
    - Users mentioned this while using the prototype.
- The past sleeping data displayed on the homepage is much more useful than the previous homepage information with live-tracking.
    - Users mentioned this while using the prototype.
- Score points being displayed out of totals makes the score easier to understand, and the lack of negative or large values is also much easier to grasp.
    - Some users mentioned this while using the prototype, and it was also remarked upon during our presentation feedback on our design decisions.
- Graph zooming is easier in the prototype since it doesn't disrupt vertical scrolling.
    - Some users who encountered this mentioned that it was easier to interact with.

Weaknesses:

- Should have recommendations on how to improve sleep score as a popup.
    - Some users tried to find this information or mentioned that it would be helpful. We also received this feedback during our presentation.
- Should have further resources on sleep metrics as links available to consumer-grade sites with more information, such as WebMD.
    - Some users tried to find this information or mentioned that it would be helpful. We also received this feedback during our presentation, specifically from Professor Fei Yu.
- Homepage should have consistent color as the other pages.
    - We received this feedback during our presentation, specifically from Professor Fei Yu.
- Sidebar should have more clarity with how views can be swapped and scrolled through.
    - Some users indicated that this was still a problem in the prototype.
- Some colors on waffle chart are difficult to differentiate between.
    - User with color deficiency indicated that this was still an issue during our analysis. Also based on general design principles[7].
- Waffle chart is still difficult to understand and alternatives to displaying it, or for other charts entirely, should be explored (e.g. removing broken hearts, displaying them alongside filled hearts, etc.)
    - Most users indicated that this was still a problem for them, and some suggested possible alternatives.

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