Linked Living

Infoviz Final Write-up

- Team:

  Noriko Misra (Kiki Liu and Derek Kuo outside Infoviz course also worked for this project as MIMS final project.)

- Project goal:

  This project aims to provide older adults and their family members an effective way to monitor heart health and activity data. To make user interface intuitive and easy to understand, I adopt various information visualization and universal design principles.

- Tasks:
  - Users understand how senior users' heart rate, exercise time, and total steps were for a day (whether they were different from usual and whether they meet their self-defined targets).
  - Users understand how senior users' heart rate fluctuated during a day and how they are related or unrelated to their activities.
  - Users understand contexts of senior users' activities during a day.
  - Users understand trends in heart rate, activities and total steps over certain time period.
  - Users explore and understand potential relationship between trends of different matrixes.

- Discussion of related work:

  The major challenges to design use interface for this project were identifying information more relevant to our users' needs and designing information visualization for both younger and older adults. I first analyzed UIs of major commercial fitness applications first and learned what kind of matrixes are used and how they are visualized. Then I also interviewed a medical professional (cardiovascular surgeon) and reviewed recent medical research papers to learn what matrixes they check and how they analyze them. Finally, to learn ways to customize UIs for users including older adults, I studied design principles to accommodate older adults.

  - UI design of major fitness application

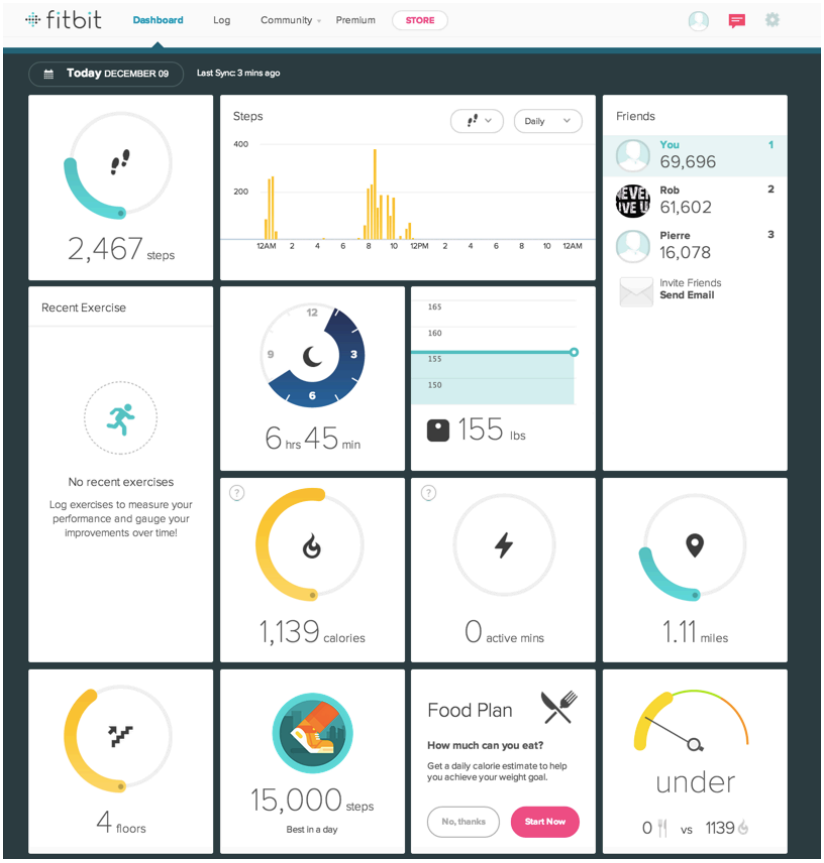
I first picked Fitbit to study their UI because they have large user base and are relatively well known among seniors. Since I am designing UI for web, I reviewed their web UI. Then I reviewed UI of Basis since their watch has various sensors like the device I use for this project (Samsung Gear S).

1. Fitbit

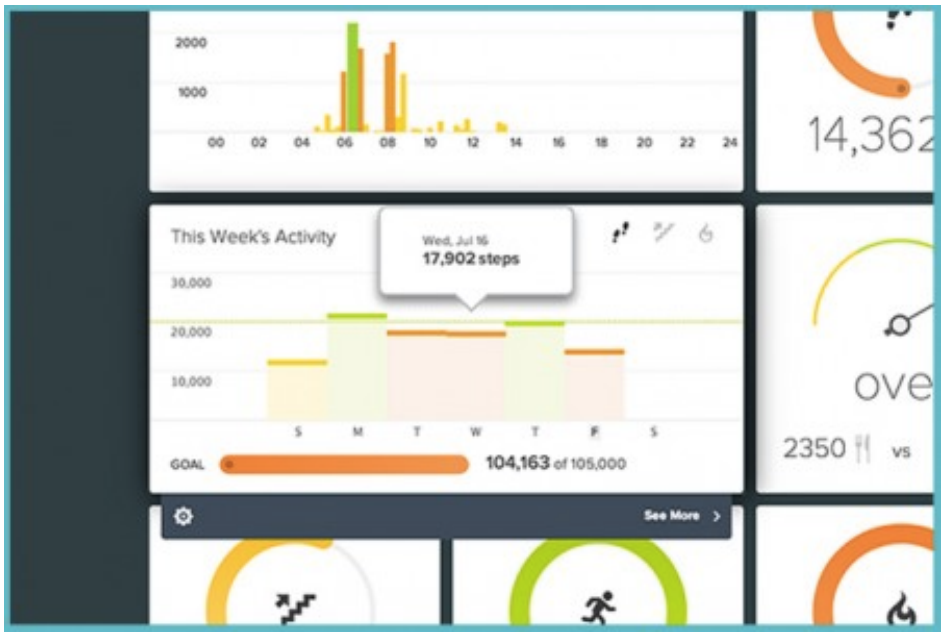
They adopt card UI design for dashboard to display various kinds of data. Interestingly they use bubble charts for many of matrixes with self-defined targets. They adopt a bar chart for steps during a day and a partial line chart for weight data. I understood that their objective with this design is simplicity; users can immediately see how much they accomplished compared to their targets. I can answer questions such as “Did I meet my target today?” “What time did I walk most?” “What time did I sleep?”. Visual elements adopt minimalist style; they look very clean and neat. Color choice is limited, which makes UI less noisy.

Major disadvantage with the UI are that it doesn’t provide users various ways of comparison. Comparison is available only with targets. I believe that many people want to think of a day more relatively. For example, I would want to ask questions such as “Was today better than yesterday?”, “Was today very different from a week ago?“. I cannot answer these questions in the UI of dashboard.

In addition to it, these visualizations wouldn’t be so useful when users don’t care about their self-defined targets much. In reality, people have different schedule and events everyday and may not care too much about daily targets as long as they can meet goals overall in a week or month.

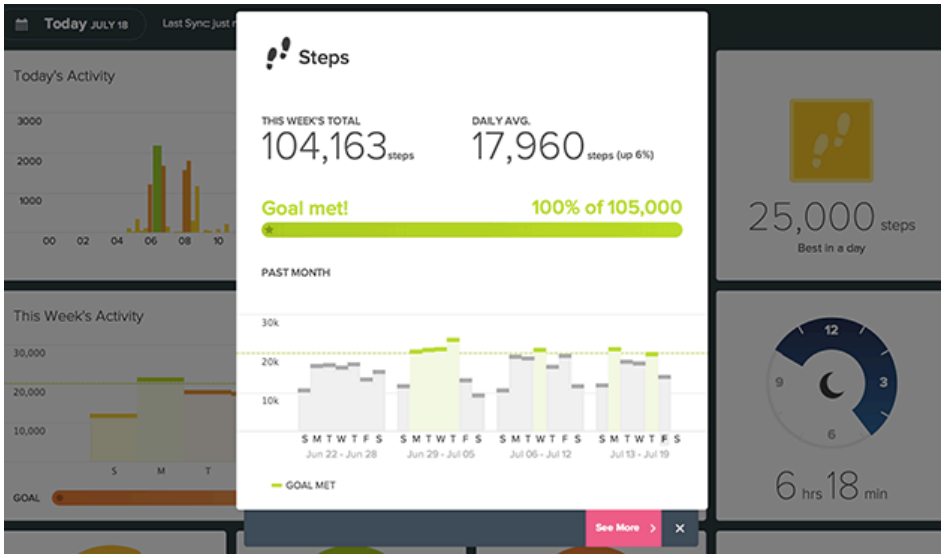


There is a summary card for activity of the week, which is a bar chart. But it is separately displayed from each matrix. Thus, I would need to check both the individual card and the summary card to understand overview, which may not be so intuitive.



To see trends, users click each card. They adopt progressive disclosure principle here. However, if a user wants to compare trends of multiple

matrixes, this is not an easy way. For example, some users may want to understand how well they sleep on days when they exercise well. Being able to look at data from such a perspective is reasonable since many studies found that exercise helps people sleep better.

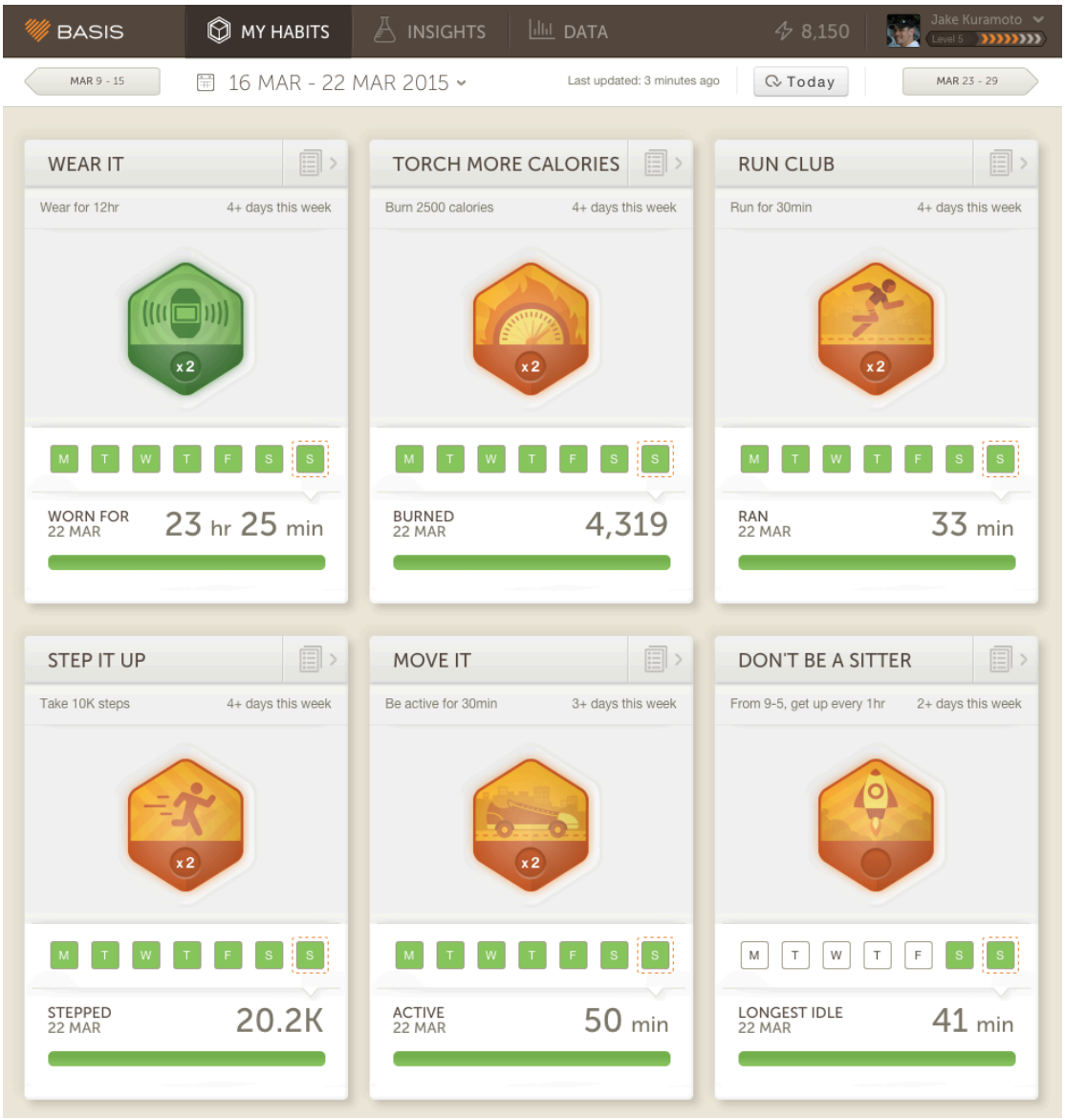


Finally, the following UI is for heart rate data from Fitbit charge. It is nice that they provide heart rate line chart together with heart rate zone and calorie burn because now users can try to see relationship. However, it is really hard to interpret data because UI doesn't show much contexts such as what was happening that time.

2. Basis

Basis organizes information based on habits, insights, and data. Unfortunately, I couldn't analyze insight UI because I couldn't find it online and didn't have one for my account. So I focus on two views: habits and data here.

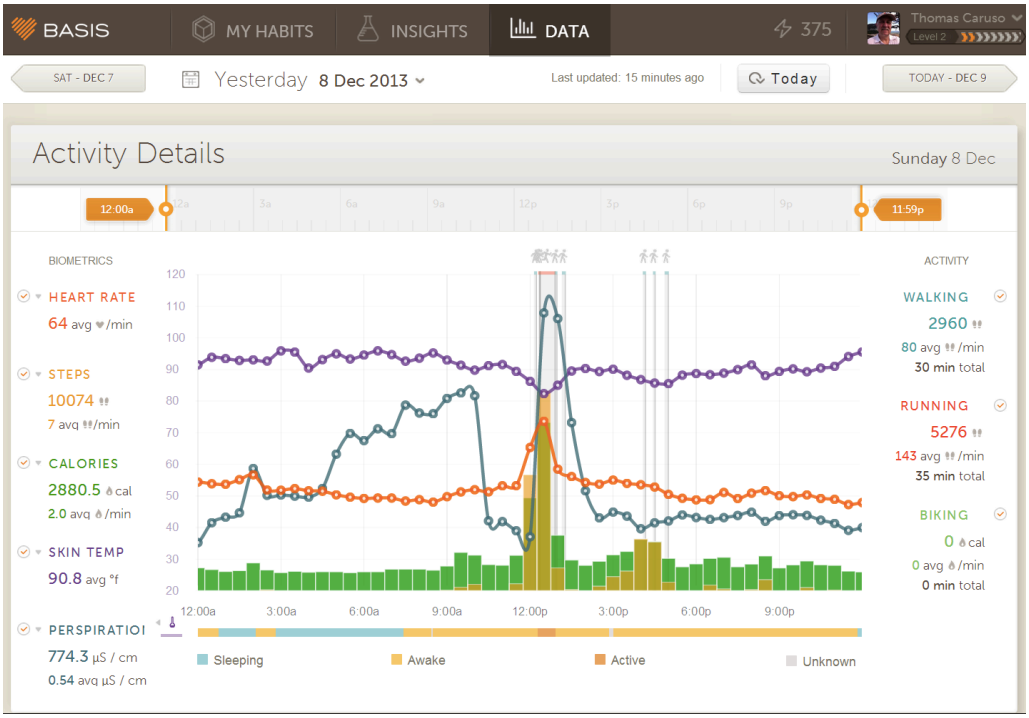
Habit view has two elements; one is coloring which days of a week a user completed a habit. The other is displaying a bar chart of a selected day of the week. One advantage of this design is that a user can immediately tell which days they have completed the habit. However, there are various problems with the design. First of all, because a user has to select a day to be able to see the bar chart, there's no easy way to compare performance of multiple days. Major space is taken to show static images instead of data, which should be main focus points. They should apply iconography more effectively. Data are all colored by green and it is not easy to quickly understand kinds of performance without checking text information around the visualizations. Users cannot easily see relationship between different habits. Patterns over time should be visualized so that users can find similar or dissimilar patterns at a glance.



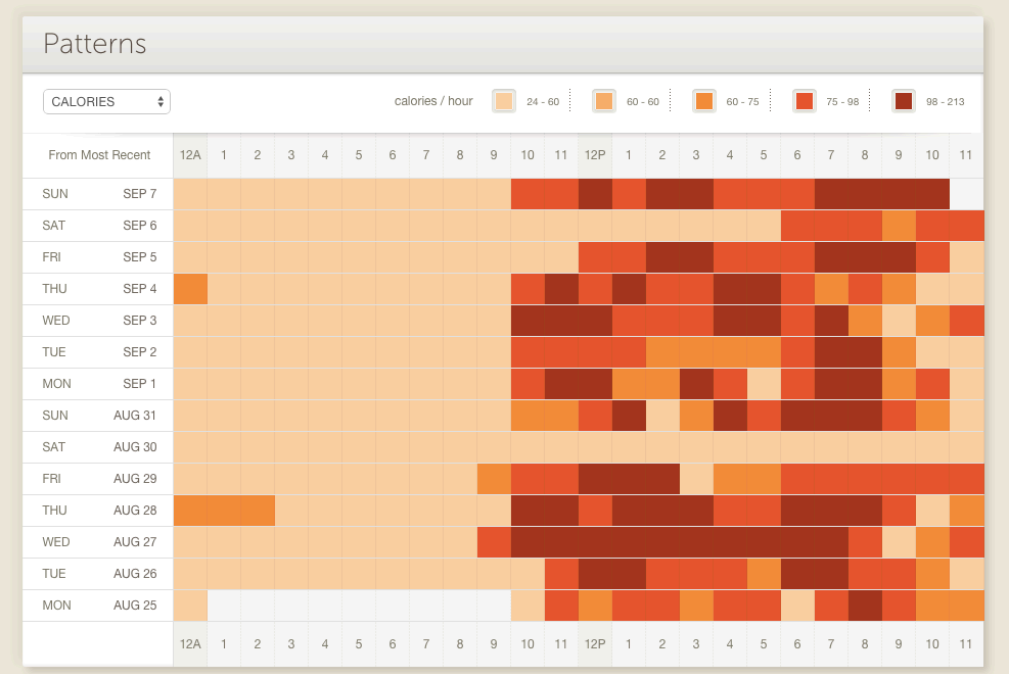
Unlike the weekly view, the data section adopts more visualizations. For trends for a relatively short period such as a day, they show one interactive graph, which allows users to select data for display. The biggest advantage of the design is that users can see activity data together with other health data (heart rate, calorie burn, steps etc). Although this graph is useful for comparison of multiple variables, I found the following problems.

- They don't have effective ways to show different scales. Although the graph shows multiple variables, the displayed scale on Y axis is just about one variable. It is not easy to understand values of data points without hovering pointers.

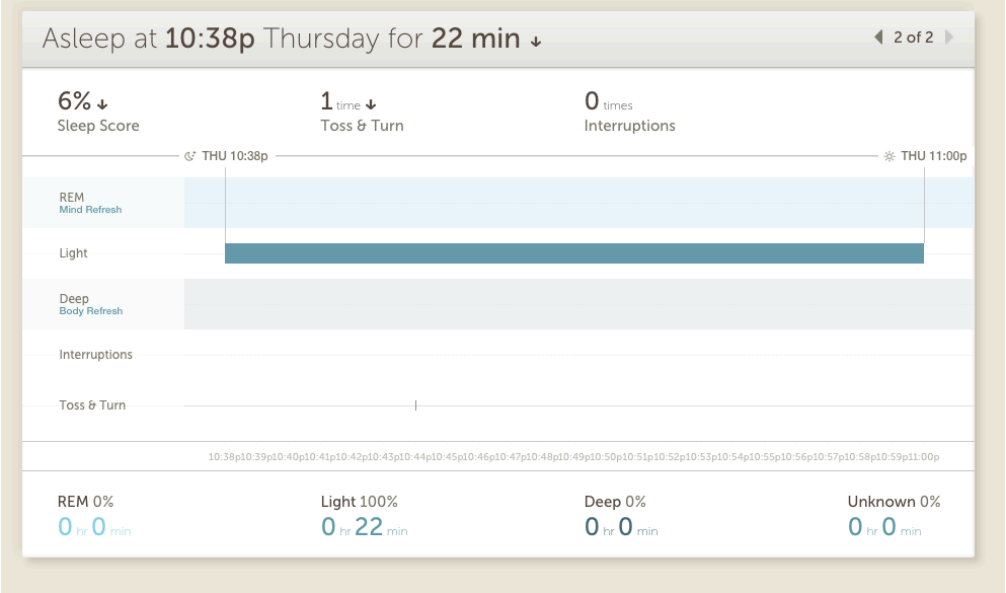
- When data points are concentrated at a small area, it is difficult to see graphs.
- Activity data is shows as background of the graph, but they are not very visible due to overlap and lack of colors.
- When data is missing, line charts start to look scattered and messy.



They also have the patterns view, which intends to display overall patterns during a day. It is a kind of heat map. Although comparison between different variables is not easy here, users can see patterns of multiple days.



Another view available in the data section is sleep display. It is a simple bar chart. Each bar indicates different types of sleep (REM, light, deep, and etc) It gives a quick overview of sleep quality. However, the time scale changes and doesn't consistently show length of sleep. They should have better presentation to indicate hours of sleep. When sleep is very short, users may not observe various types of sleep. It can change interpretation of data.



- Design principles to accommodate older adults

Farage et al[1] researched age-related functional changes and provided guidelines to accommodate older adults. While elderly's functional changes happen with various sensory systems, I would like to focus on those in visual and cognitive aspects, which are more relevant on graphical user interface. To improve visual perceptibility, high contrast on-screen and warm color choices are recommended. In addition to it, visual presentation should be simple and easy to see. Space allocation should match priority and importance of information. Supporting cognitive process of older adults, it is important to understand that older adults can often keep procedural memory, which is memory of "how to carry out tasks learned in the past" such as automatic, habitual behaviors. Same as their attention capacity, procedural memory can be processed more slowly as people grow older. But it is easier for them to do tasks that they are already familiar than completely new tasks. Thus, commonly used visual presentation can be more digestible for seniors than something very novel.

- Other findings from recent medical research

I learned by interviewing a cardiovascular surgeon that continuous heart rate monitoring by optical heart rate sensors is not common in the medical field. However, he emphasized two points. One is the importance of interpreting heart rate data with activity data such as sleep and exercise. Reflecting his comment, medical research papers often heart rate at rest and heart rate during sleep to study correlation with mortality rate or cardiovascular risk. Another point is that doctors and researchers often pay attention to outliers. In fact, maximum heart rate is often used in medical research. I also decided to use percentage of time with heart rate above certain threshold (100, 180) as quick filters to detect percentage of time with relatively or abnormally high values.

❖ Tools and data used to accomplish the goals.

Device	Samsung Gear S
Sensors	heart rate, pedometer, light sensor, and gps
Input Data from sensor	● heart rate: An attribute to indicate the heart rate in beats per minute. ● pedometer: Current activity - Running, Walking, Not Moving Speed Cumulative total step count - Cumulative walking and running step count since last start.

[1] Farage, M. A., Miller, K. W., Ajayi, F., & Hutchins, D. (2012). Design Principles to Accommodate

	● light sensor: Ambient light level in lux. ● gps: Latitude, longitude, speed, timestamp
Other data source	Weather and temperature data from open data source
Output	Providing seniors, their family members and caregivers summary of heart condition, overall mobility, and exercise with visual storytelling UI in our web platform.

❖ Steps required to accomplish goals

I, together with my teammates, followed the steps below to execute this project. For front-end development, we decided to use Google Charts after considering High Chart, Metrics Graphics, D3.js, and Fusion Charts. We customize the attributes from combo chart template and enable varied charts (bar chart, line chart and area chart) working smoothly within one SVG. More comprehensive documentation of each step is available in our MIMS final project report (http://www.ischool.berkeley.edu/programs/mims/projects/2015/linked_living).

1) Conduct macro trend study
2) Conduct user study and interview with a medical professional
3) Conduct initial exploratory data analysis
4) Develop algorithm for activity detection
5) Study UI of related work and design UI for the webplatform
6) Develop the website
7) Conduct usability test

❖ Results from usability test

I obtained feedback from three people at age 60-70 and five people at age 25-35 for usability test[2]. I requested the following tasks;

1. Daily digest: Explain what information on the UI is about.
2. Daily digest: Explain how healthy the user of the data based on the data visualizations.
3. Daily digest: Explain contexts of the user's activities based on the data visualizations.
4. Trends: Explain what information on the UI is about.
5. Trends: Compare patterns in different matrixes and explain what is observable.
6. Trends: Provide comments for the user.

I asked participants to fill a questionnaire using likert scale for the following statements.

[2] Usability test guide is available in Appendix 2.

Statement 1	The tasks were easy to complete.
Statement 2	I felt lost after given the tasks.
Statement 3	I understood the navigation system throughout the website.
Statement 4	I found information on this website useful.
Statement 5	I found the experience of using this website enjoyable.

Answer options for all the statements were (1) Strongly disagree, (2) Disagree, (3) Not sure/undecided, (4) Agree, (5) Strongly agree.

Fig. 8: Answers to questionnaire (older adults)

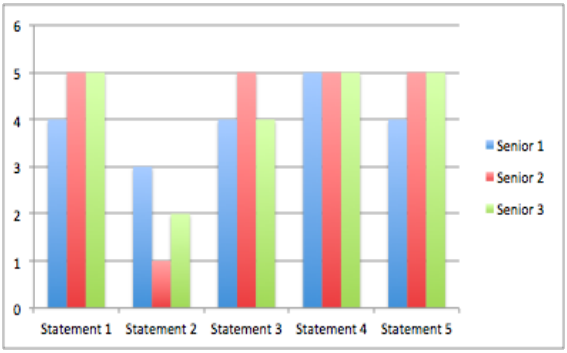
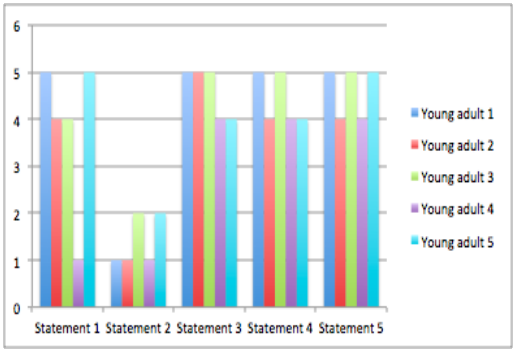


Fig. 9: Answers to questionnaire (younger adults)



As shown in Figure 8 and Figure 9, most older and young adult participants gave positive feedback to difficulty of task, navigation system, usefulness of information, and overall experience. Only one young adult strongly disagreed with statement 1. However, his feedback through the session and written comments did not mention difficulty of task. He might have mistakenly chosen the answer option 1 for statement 1.

<Participants of usability study>

	Sex	Age	Education	Living condition	Technology use	Occupation
1	F	70	College	Alone	iPhone Macbook	Retired
2	M	late 60s	College	With wife	iPhone Desktop	Retired, but actively involved in volunteering activities
3	F	late 60s	College	With husband	iPhone Desktop	Retired, but actively involved in

						volunteering activities

	Sex	Age	Situations of elderly family members	Ways to communicate with family
4	M	late 20s	Grand parents living by themselves	Phone call, occasional visit
5	F	late 20s	Grandmother in 80s living close to her son	Phone call, occasional visit
6	F	late 20s	Parents in 60s living by themselves and aunts with health issues living with their own children	Skype
7	F	late 20s	Parents in 50s living by themselves	Phone call, frequent visit
8	M	late 20s	Grand parents living in a foreign country	Occasional phone call and visit

Major feedback on data visualization:

- Participants including seniors were able to figure out what each graph is about. Older adults tended to take 3-7 seconds more than younger people due to lack of familiarity. However, they were all able to understand meaning of graphic elements in graphs such as bars, lines, and different color uses.
- Participants generally liked the look and feel of interface. One said, “I like the warm color choice, look and feel wasn’t intimidating.” Another person told, “I like the aesthetics and also the large visual emphasis on the timeline, showing the persons' activities throughout the day.”
- Participants looked for more clues for interpretation. During the session, I repeatedly observed participants asking question, “Is this good or bad? Do I need to tell or do something for my parents/grandparents?” Most participants didn’t recognize supporting information for data interpretation in the right part of the trend view. One person said that she wishes the system could tell her what has to be done. Although I provided reference points such as average heart rate of the same age group or self-defined targets, they were not completely sure how to interpret the data.
- Different scale for each graph in the trend view can confuse users. Three people pointed out that graphs in trend view use different scale, which could be a bit confusing. One person suggested using one graph with multiple lines.

- Filter in the trend view takes too much space and makes chart invisible. Three participants could not clearly see graphs below the filter section in the trend view. One person said that a different composition might work better. Their eye focus should easily land at graphs.

Future consideration:
I was especially intrigued with data interpretation process by users. Our data has ambiguity. There may be errors. Even if there is no error, it is still difficult to judge whether a particular value is within a normal range or not. There are variations among individuals, timing, external environments and etc. Data of these factors may not be available in our system. Users cannot answer their ultimate questions such as “Is the person of the data all right?” easily although that is how they look at the UI. Simple reference points such as self-defined targets and average of particular age groups would not solve this problem.

After discussing possible solution to it, my team came to realize that human experts are likely to do much better job than automated analysis by a machine. I researched approaches adopted in businesses that have similar problems and found an interesting mobile app. Rise, a mobile app for diet control, uses nutrition experts who review users’ meals and give one to one advice. I believe that I can take similar approach and include human experts (e.g. nurse practitioners) who can play a role of a coach for seniors and their family members and support data interpretation. Our platform can be a collaborative space where users and experts have effective monitoring and communication with actual data. I believe that this is a promising idea and hope to conduct further study.

❖ Links to demos, documents, or whatever is needed to show the visualization.

http://people.ischool.berkeley.edu/~kikiliu/server/daily

We share our code in Github.
https://github.com/kikiliu/Linked

❖ My role in the team

I conducted macro trend study, user study, initial exploratory data analysis, reviewed related work and designed UI for the web platform. I created an interactive mock up for the web platform by Axure (available in the following link: http://oka5ia.axshare.com/home.html) and from that point, my teammate, Kiki, who was responsible for front-end development, took over to complete prototype. I created all the image files required for the

design. Then, I conducted usability test for the UI. My teammate, Derek developed programs for data processing in backend.