

Personal Health Data: Visualization Modalities and Their Perceived Values

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ABSTRACT

In this paper we focus on universal human values as defined by Schwartz [Schw92] in the context of visualizing personal health data. Can data visualizations convey human values? We have explored various modalities of presenting health data and found that personal health visualizations indeed can convey values. This is currently work in progress, an initial step towards value-based design in the area of data visualization of personal health data.

Keywords

Data Visualization, Physical Visualization, 3D Visualization, Activity Tracking.

1. Introduction

Healthcare is rapidly becoming more expensive; a report by the OECD shows that the percentage of healthcare expenditure of GDP (Gross domestic product) will rise for European countries [MaO113]. In general, each country will have to provide better Healthcare using less money in the future. These rising costs can be attributed partially to the growing inactivity of people: “It is now more deadly than smoking” [Macc13].

In this context, wearable activity trackers are seen as a promising way to counter this disturbing trend: these intelligent wearable devices help users quantify the amount of steps taken and the heart rate throughout the day and thus provide people with insight about their health and possibly motivate people towards change. Earlier research in the domain of digital health and wearable activity trackers focuses mainly on translating sensor readings, such as acceleration, into a number of steps, or energy expenditure [CrCB06], but the relationship between activity trackers and their potential user group, however, has not received the same attention: for example, it is still unclear what motivates people to start tracking and how people make use of the gathered data. An important study in this area found that reasons for people to start tracking their activity

seem to relate to the human values they hold dear, rather than specific things they want to measure or specific goals they want to reach [RRMC14].

This finding implies that, for example, Nike Fuelband users would wear the product because their values resonate with Nike’s brand identity; they might identify with and feel motivated by the slogan: “*Life is a sport, make it count*” [Nike12].

This leads to the question: can personal health visualizations convey, attach to or support human values? This is especially important for novice, casual, or non-technical users who often have difficulties dealing with and interpreting the notion of “data”. Based on this question, we form the hypothesis that the value of visualization is closely related to the modality in which it is presented.

In the following, we will first elaborate on related work, then describe a short study, in which values related to activity trackers are explored, building on a suggestion by Rooksby et al. [RRMC14] Next, we will explore different modalities of presenting personal health data and discuss them and their implication for values. The paper concludes with a summary and direction for future research.

2. Related research

Visualizations that relate to universal human values as defined by Schwartz [Schw92] can be found in many ways and representations. An inspiring way of visualizing a single heart rate signal was created by Jen Lowe, who visualized just her heartbeat, but then contextualizing the signal in her complete expected lifespan, which is a simple, yet deep approach to data visualization [Lowe14].

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	Nike Fuelband	Withings Pulse	Jawbone Up	BodyMedia Band	Fitbit Flex	Basis B1
Discriminator	Nike brand authority, 'fuel points'	Can be worn unnoticed, heart rate sensor	Includes meal and emotion tracking	Precision, focus on weight-loss	Social leaderboards	Contains most sensors of all.
Slogan	"Life is a sport, make it count"	"Track. Improve"	"Know yourself, live better"	"The leading on-body monitoring system"	"Make fitness a lifestyle with flex"	"The world's most advanced health tracker"
Emotional Benefits	Collecting 'fuel points'	Discretely tracking activity during the day	Support during the day to live healthier	Ensuring weight loss	Competing with friends	Exploring health using multiple
Value	Hedonism (Enjoying life)	Achievement (capable)	Tradition	Security (health)	Power (social recognition)	Curiosity

Table 1. Differentiating between the activity trackers based on discriminators, slogans, and emotional benefits. From these elements, a matching Schwarz value has been selected.

The weather bracelet by Mitchell Whitelaw [Whit09] shows how a simple visualization of weather data can evoke "a sense of preciousness" purely by presenting it in a physical shape. This is a prime example of how the modality in which data is presented is able to influence it's the perceived value.

Rooksby et al. [RRMC14] have looked at personal tracking and propose that rather than relying on one single app or product, people "interweave", as he puts it, a multitude of apps. Consequently, data is scattered over various products, apps and services, resulting in a fragmented view of one's health.

The Health Mashups [BTSL13] concept has proved the usefulness of a system that aggregates data from various sources in order to find trends that relate to an individual's well-being and promote behavior change. For their system they chose to use natural language to provide the user with "significant observations". This leaves room for us to study the visual representation and exploration of such data sets.

Value Study

As the first step, a benchmark study involving various activity trackers was carried out, comparing both product features and product marketing elements. The activity trackers included in this study are the Nike Fuelband [Nike12], the BodyMedia Band [Body13], Withings Pulse [With14], Jawbone Up [Jawb13] and Fitbit Flex [Fitb14]. Feature-wise these devices are all quite similar; they have integrated accelerometers for counting steps throughout the day and Bluetooth (Low-Energy) for smartphone connectivity and synchronization. Some tracking devices have other sensors integrated to measure additional physiological parameters such as skin temperature. To differentiate between the

devices and their intended use, slogans and marketing material have been analyzed (Table 1). From this, (intended) emotional benefits and the correlating values have been derived, based on Schwartz's Universal value model [Schw92]. Visualizing the devices in the model provides us with the distribution as shown in Figure 1:

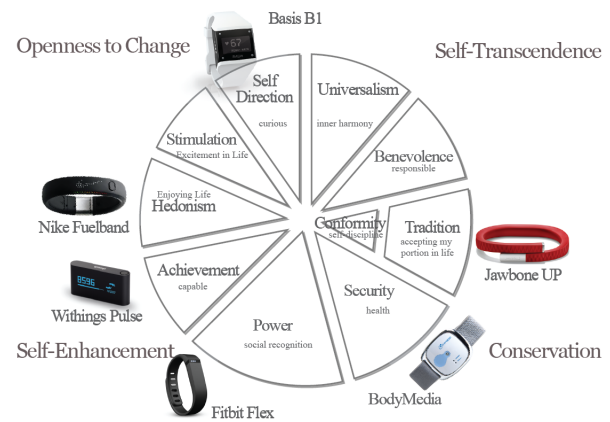


Fig 1. Activity tracking devices mapped on Schwartz's universal value theory (Schwartz, 1992)

The investigated tracking devices can be associated to various values. For instance, the BodyMedia band is especially aimed at people who feel insecure about their weight, hence their partnership with a TV-show [Coms12]. The work of Le et al. connects heart rate measurements and group's activity visualized as abstract avatars to an increased feeling of connectedness, which is directly related to human values as shown above [LFH13].

3. Method

In order to study visualization we first gathered personal health data. One device in specific has been used to gather data; the Basis B1 (Fig. 2). This device

was chosen because of its wide range of available sensors:



Fig 2. The Basis B1 [Basi14] watch used for gathering health data

The Basis B1 is capable of detecting and recording heart rate (beats per minute), galvanic skin response (microSiemens per centimeter) and skin temperature (degrees Celsius), as well as the user’s steps and activities (walking, running, cycling). Measurements are done in one minute intervals, and the data was extracted from the watch using a modified version of a script that is able to access the Basis API [Tro13].

Visualizing personal health data

Using the data gathered from the activity tracker we have explored several ways of visualizing the data, attempting to investigate how the representation of data can influence its interpretation by end-users. We suspected that exploring extreme cases in our study would give us a better view on the research question than exploring several slightly different cases. Therefore, the four cases (A-D) range from digital to physical representations of health data.

3.1.1 Case A: Dashboard

The first case is a typical dashboard style visualization of one’s health data, using standard line graphs and interactive elements to zoom in and toggle the visibility of individual data streams.

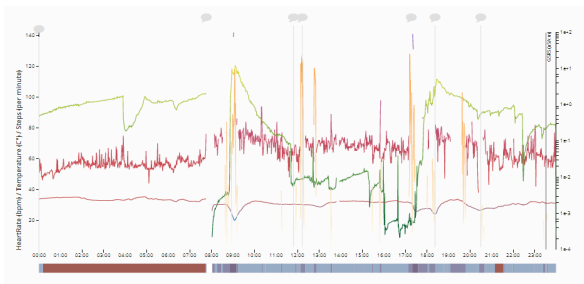


Fig. 3. A dashboard view of the data

The dashboard contains multiple views; other views are averages per day and mean value per time of the day (e.g. average skin temperature at 8.00 AM) (Fig. 4). These views all inform the user, albeit in a traditional way.

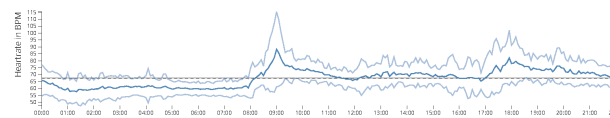


Fig. 4 Average heart rate per time of the day on timeline (incl. standard deviation).

3.1.2 Case B: 3D visualization

The Processing software package [FrRe13] has been used to map and visualize the measured physiological parameters. Each day is represented with a line graph; layering these simple graphs in 3D space, creates a new dimension (the “date” axis), resulting in a three dimensional “data landscape” (Figure 5a and 5b). The visualization is interactive, meaning it is possible to pan, zoom and rotate to change one’s view on the data. Especially during these actions the user gains more insight into the structure of the “data landscape”, such as common patterns over multiple days.

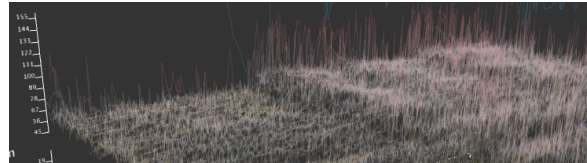


Fig. 5a: Cropped version of Figure 5b to better show the layered line graphs.

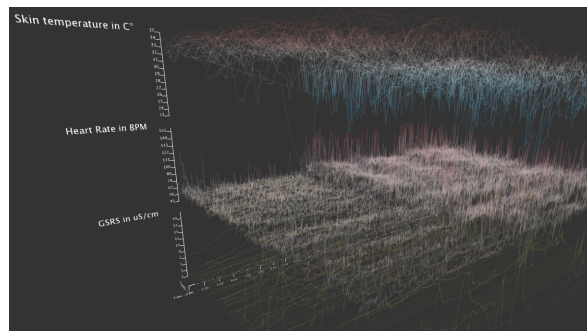


Fig. 5b: Visualization of skin temperature, heart rate and skin response over multiple days.

3.1.3 Cases C and D: Physical visualizations

Janssen et al. [JaDF13] found that physical visualizations can provide a better experience to people performing analytic tasks on 3-dimensional data. Especially since physical visualizations afford being touched as opposed to on-screen visualizations. This was the basis for our decision to include physical visualizations in our comparison as well.

Two custom physical visualizations from personal health data have been created to explore how physicality influences interpretation of the data. Three channels of data have been used, namely heart rate, skin temperature and galvanic skin response.

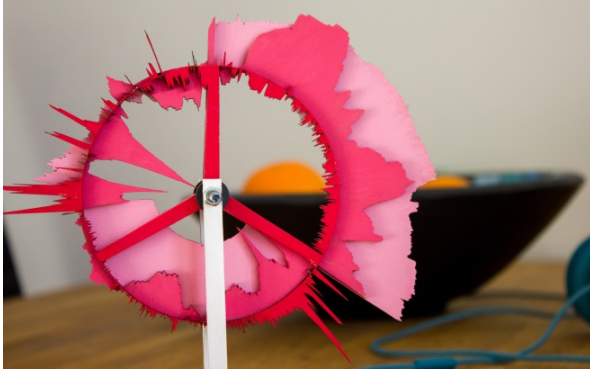


Fig. 6: Wooden data display. Back to front: heart rate, skin temperature, skin response (C).

The first prototype (Figure 6) is a two dimensional wooden radial display of the data, where the mean is represented by the “visible” circle, and deviation from the mean is emphasized: peaks outside of this circle represent values above the average, while peaks inside the circle represent values below average. The circle itself represents 24 hours of data starting at the top; data points from 8 A.M. will be at 1/3 of the circle, while data from 8 P.M. will be situated 180 degrees (12 hours) further in the circle. The three data channels consist of stacked laser-cut shapes, aligned by their mean value circle and given different colors to ease comprehension. The mean makes a suitable reference to ease the interpretation of the visualization: for example, one can easily distinguish sleeping from being awake by the skin temperature (middle layer), as this parameter rises far above average during the night and lowers immediately when waking up. Recognizable daytime activities are active sessions outside, where skin temperature drops below average and heart rate rises considerably.



Fig. 7: Radial display with data aligned on a different axis (D).

The second prototype (Figure 7) does not rely on the deviation from a mean value. Instead, data is distributed over a circle with a fixed radius, representing 24 hours. Height describes the absolute data value, creating a fortress-like structure. The central circle is even obscured by the two outer circles. This can be overcome by more careful scaling of data, but this would skew the relation

between the various graphs, since these are not deviations from the mean. Interaction is possible by rotating the structure around the central axis; this allows viewers to more easily “skim” through the data, since it isn’t possible to view all data points simultaneously using this kind of data sculpture.

4. Discussion

Visualization A is a conventional dashboard. It taps into conventions about information visualization set up by experts [Tuft90]. Such a visualization works well for people who have experience in reading graphs and want to view raw data in an acceptable format; in Schwartz’s terms: people who value “tradition”. The value of such a system is in its accuracy and neutral representation, supporting user in retrieving correct values at any given point in time.

Visualization B also follows conventions, but breaks with A by providing an extra spatial dimension that is used to incorporate more data while maintaining the granularity of the main timeline. This creates an interesting representation of one’s health over multiple days, rather than during one single day (compared to A). This visualization allows observers to quickly spot recurring (daily) patterns and structures over larger periods of time. For instance, Figure 5 shows clear patterns around 8.00 and 17.00 every day. This information might be more difficult to find in a two dimensional visualization without a representation of more than one day. This implies that case B trades accuracy for a more global view of the sensor data and allows for exploring a single “data landscape” rather than multiple individual graphs. Because of the added temporal element, it can be argued that proposal B is more related to the value of long-term feeling of “security” in figure 1. B gives a clear overview of how health metrics change over time, ensuring that people can spot any negative changes early on.

Cases C and D differ from A and B because of their physicality. Both C and D do not contain a scale; the various data layers are scaled to emphasize the fluctuations improving visibility and comparability in all three layers. This visualization focuses less on accuracy and absolute values, and instead creates a more understandable tangible representation: It emphasizes the fluctuations rather than the scale.

As with many physicalized representations of digital or intangible concepts, cases C and D are, on the one hand, static representations that are bound to a snapshot of data and do not allow for the dynamic display of changing information. On the other hand, physical artifacts are always present, unlike a screen that can be switched off. This allows these artifacts to occupy a different position in the user’s life and therefore convey different values to the user than virtually displayed data can. Additionally, physical artifacts that represent personal data inherently may have a sentimental value caused by their physical and

non-generic nature; they are an embodiment of one's personal data. This idea has also been suggested by Michael Whitelaw in a reflection on his "weather bracelet" [Whit09].

Between C and D, few differences can be noted, D might seem like a slightly modified version of C. However, in D, physical interaction is required to browse through the data; this would make D a more 'engaging' visualization while C is a visualization that does not require engagement with its viewer; it provides an instant image of the data, making it easier to compare data between various periods of time, while D always requires interaction to get the complete picture. This slight difference in appearance turns out to have a large impact on the conveyed value of these artefacts.

Conclusively, visualizations A and B seem to be related respectively to 'tradition' and 'security'. C and D seem to relate to 'self-direction', including sub-values like 'creativity' and 'curiosity' [Schw92]. D nudges towards stimulation with the added notion of interactivity.

5. Conclusions and Future Work

In this paper we have shown that personal health visualizations indeed can express values, by presenting several cases in which data is presented in different modalities and discussing how these relate to values. We found that the various modalities can be positioned in the Schwartz model based on their conveyed values.

This work in progress study is a first step towards a deeper investigation of values of various modalities of presenting data in the personal health context. Future research should focus on validating and extending the suggested modality-value links through more detailed user studies. Other hybrid modalities of data visualization can be included in future work as well. Physical overlays for screens with digital information and wearable artifacts with embedded digital information displays are examples of such modalities, blending dynamic displays together with tangible objects.

Additionally, the role of contextual data aggregated from external sources can be researched. Together with values, contextual data is presumed to be a decisive element in what modality of visualization to use; think about contextual user interfaces, adapting to the user's location and activity. Such a scenario is also possible for presenting data based on contextual information.

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