“In Your Face!”: Visualizing Fitness Tracker Data in Augmented Reality

Sebastian Rigling
University of Stuttgart
Stuttgart, Germany
sebastian.rigling@visus.uni-stuttgart.de

Xingyao Yu
University of Stuttgart
Stuttgart, Germany
xingyao.yu@visus.uni-stuttgart.de

Michael Sedlmair
University of Stuttgart
Stuttgart, Germany
michael.sedlmair@visus.uni-stuttgart.de

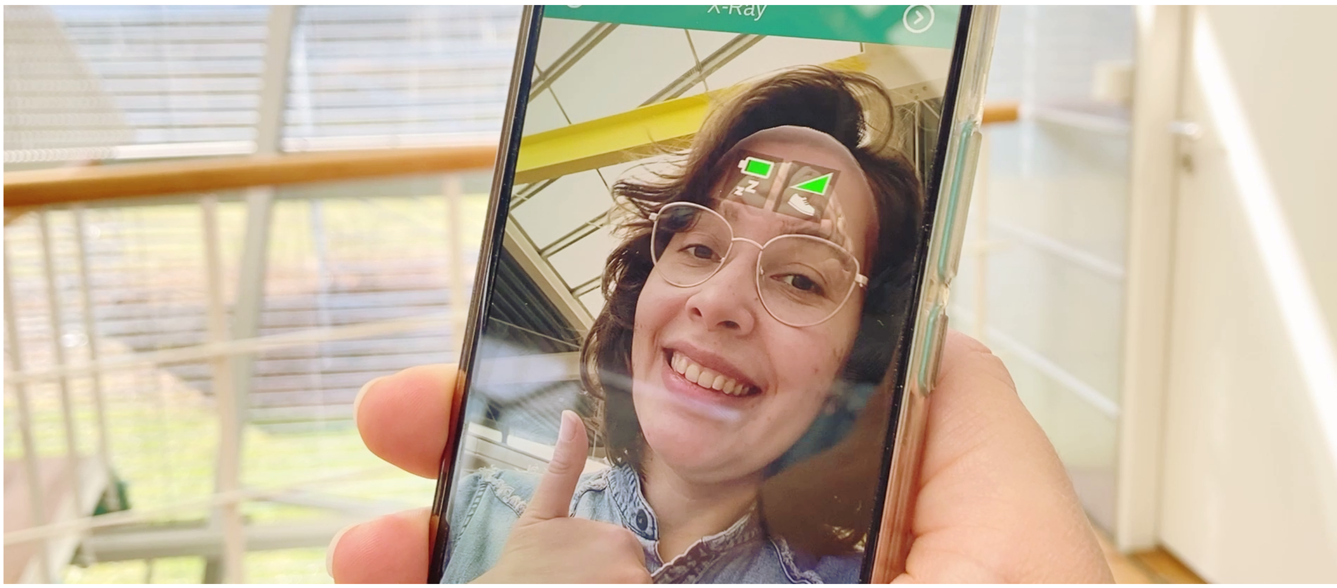

Figure 1: Our app prototype visualizes fitness tracker data “in your face.”

ABSTRACT

The benefits of augmented reality (AR) have been demonstrated in both medicine and fitness, while its application in areas where these two fields overlap has been barely explored. We argue that AR opens up new opportunities to interact with, understand and share personal health data. To this end, we developed an app prototype that uses a Snapchat-like face filter to visualize personal health data from a fitness tracker in AR. We tested this prototype in two pilot studies and found that AR does have potential in this type of application. We suggest that AR cannot replace the current interfaces of smartwatches and mobile apps, but it can pick up where current technology falls short in creating intrinsic motivation and personal health awareness. We also provide ideas for future work in this direction.

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CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**; *Visualization*; • **Applied computing** → Consumer health.

KEYWORDS

augmented reality, fitness tracker, health, visualization

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1 INTRODUCTION

Given larger trends in medical challenges of this decade, such as the increasing elderly population, the physician shortage, and the COVID-19 pandemic, many researchers look for ways to improve public health and health awareness. One potential way to improve public health and health awareness is through personal quantification and visualization [10].

In recent years, fitness trackers have rapidly gained popularity and have become almost as ubiquitous as smartphones. Between 2017 and 2023, the number of fitness/activity tracking wristwear quadrupled [17]. Now, many consumer-oriented smartwatches include fitness-tracking capabilities with built-in sensors and software features to measure steps, heart rate, sleep duration and quality, stress, and more.

The increasing public interest in personal quantification through fitness tracking has various reasons such as the pursuit of weight loss, behavioral changes, or a more healthy lifestyle in general. Evidence supports the significance of health benefits from prolonged use of these devices, but about a third of users abandon their trackers after only a few months of usage [2]. Attig and Franke [2] created design guidelines, which are meant to counteract the driving factors in the abandonment of fitness tracker wearables, such as increasing autonomous motivation, user identification, and support on reflection. We assume that augmented reality (AR) might offer a novel approach to mitigate these challenges in personal quantification.

AR has seen widespread use in medical use cases, e.g. teaching gross anatomy to medical students [21] and surgical simulation [12]. In the fitness context, AR has been found to both improve exercise execution, e.g., through movement guidance and visual feedback, and to increase the enjoyment of the activity and thus motivation [19].

In our work, we wish to combine the benefits of medical and fitness applications of AR through the visualization of fitness tracking data. We envision that in the longer run, such approaches might open up a completely new way to how people interact with, understand, and share personal health data. By presenting personal health data in the context of the user's own body we intend to improve the user's identification with and understanding of their own or others' personal health data and consequently raise health awareness. In other words: we want to investigate a "fitness vision superpower" similar to the "emotion vision" proposed in *Superpowers as Inspiration for Visualization* by Willet et al. 2021 [22]. To this end, we explored various aspects of designing AR applications for visualizing fitness tracker data to further the understanding of the design space as a whole. We created an app prototype (Fig. 1) with five different filter designs and conducted two small-scale preliminary studies in order to compare the AR approach with the currently prevalent health apps.

Our main results suggest that aesthetic pleasure, fun, and emotional feedback are valid ways in which AR can create added value, on condition that the data remain readable and additional more detailed information can be accessed on demand. We also found that users are less likely to use AR in a mobile setting, e.g., on the go, as it lacks the glanceability of a smartwatch interface. Furthermore, our results suggest two main directions for future work: a) supporting self-directed health/fitness reflection using ambient visualization in a mirror-based setup; b) AR in social interaction for reading and understanding the health/fitness status of others, as it can be used in medical examinations and by sports instructors in fitness classes.

2 BACKGROUND AND RELATED WORK

At the core of *personal quantification* and the related scientific field of *personal informatics* is the goal of gaining insights and information from quantifiable, sensor-driven data about oneself—the "quantified self" [11]. Fitness trackers are a very common means of personal quantification. With advances in wearable sensor technology, higher fidelity and a wider range of collected data are possible. There have been several works on the impact that fitness trackers have on users' motivation and activity [1, 6]. Motivation is driven by many factors, including data visualization [24].

There are also approaches that go beyond 2D on-screen visualization of fitness tracker data. In a data physicalization approach, Stusak et al. [18] used activity data to create abstract sculptures. Schneegass et al. [16] used a wearable on-body display in a t-shirt to show the wearer's heart rate right above their heart. In the same sense, we want to extend this work and go beyond 2D visualizations, using the user's body as a canvas for the visualization of fitness tracker data.

The human body is the focus of many AR applications, especially when the virtual content (data) relates to the human body itself. Therefore, prime examples of such AR applications can be found in the medical field and date back to the early 1990s, like visualizing ultrasound imagery within patients (1992) [3]. Medical applications include teaching gross anatomy [20, 21], as well as surgery training (simulation) and assistance [12].

As consumer-oriented mobile devices, i.e. tablets and smartphones, became capable of running AR applications, it opened up a playful approach to AR to a wide audience. Well-known examples are selfie camera filters provided in instant messaging and social media applications such as Snapchat and Instagram. These AR filters use video face tracking technology to change the user's appearance in photos and videos, changing facial features, hair and eye color, adding (prosthetic) makeup effects, etc. Fribourg et al. [7] investigated how these changes can have a psychological impact on self-perception. Their work suggests that AR filters can be used to trigger specific responses or emotions in users, which is related to our goal of creating intrinsic motivation through the use of such filters.

In addition to personal social media use, research has explored how face filters can be used for various purposes such as marketing and entertainment [9]. This research has shown that playability (i.e., the fun and enjoyment that comes from using the face filter) is the key factor in user satisfaction. In the initial design phase, this should also be considered for other purposes like ours.

The concept of AR face filters is not new in science. From a technical perspective, it is no different from any other AR setup with a display that shows a mirrored live video of what is in front of it. In literature, these systems are referred to as *mirror-based AR*, *AR mirrors*, or—adopted from the system of the same name by Redaelli et al. [14]—*Magic Mirrors*. Whereas mobile devices are specialized in detecting and tracking human faces, bigger screens allow full-body tracking. For this reason, these AR systems have been used in health-related contexts like medicine (e.g., anatomical learning [4, 5]), and physiotherapy (e.g., motion guidance [19, 23]). Thus, our AR mirror approach for public health and raising health awareness fits seamlessly into existing work.

3 PROTOTYPE DESIGN

In our design process, we started with an unstructured brainstorming session to identify use cases (i.e., the ways how users gain

(a) Make-up **(b) X-Ray** **(c) Cartoon** **(d) Tech Brain** **(e) Pet Brain**

Figure 2: Examples of the 5 filter designs we created for the app prototype.

insights through personal quantification) and possible design space variables. As an outcome, we divided the use cases into two major categories. One is Historic Comparison for tracking personal changes over the course of several days (i.e., changes in sleep duration and step count). The other is Self-Reflection for reading the latest (or real-time) health data providing information about the current state of the body (i.e., heart rate, and stress level).

Our goal was to explore a variety of different visualization ideas across the design space that reflect the identified variables: readability, aesthetics, and playfulness. In total, we created five different visualizations, which we see as the first step in an iterative design process. Two for the Historic Data use case (Fig. 2a–b) and three for the Self-Reflection use case (Fig. 2c–e):

- **a) Make-up**. Abstract shapes convey the number of steps and hours of sleep for each of five days. A golden dot indicates that the personal goals of the respective day have been met.
- **b) X-Ray**. Trends from historic data are presented as aggregated battery level (sleep) and signal strength (step count) of the brain which is shown through a simulated x-ray view. Brain color and size also reflect positive and negative trends. A speech bubble provides additional feedback to the user.
- **c) Cartoon**. Comically exaggerated facial expressions reflect stress levels (dark scribbles or colorful flowers circling around the user's head), sleepiness (dark circles under the eyes), and heart rate (red cheeks, a pale face, or pulsating bright red veins).
- **d) Tech Brain**. Dial indicators on the user's brain visualize the current health data. The brain reacts to changes in values, e.g., for "critical" levels of stress, the brain emits smoke.
- **e) Pet Brain**. The brain reacts to changes the same as *Text Brain*, but instead of the dial indicators, the brain has a face and current health data is encoded as emotion. A speech bubble provides additional feedback to the user.

We implemented the visualizations for Android smartphones. The user interface is designed to provide a similar user experience to the mirror-based AR applications ("selfie filters") that users are familiar with. We used the *ARFoundation* framework from *Unity*[1] and Android's *ARcore* face tracking feature to dynamically map the visualizations onto the real-time video image of the user's face. Fitness tracking smartwatches (*HUAWEI*, *Fibit*, and *Samsung*) obtain historical and real-time data that would be used within our application. For simplicity and privacy concerns, the access to APIs to automatically retrieve personal health data directly from the fitness tracker or user's health app has not been implemented. Instead, the app shows fields for manual input on the start screen. We deemed this approach to be sufficient for our goal of initial design space exploration. On the press of the *Start* button, the app starts the AR mode. With the *Next* button, the user can switch between the different filter designs. The order in which the data presentations were displayed was counter-balanced across participants.

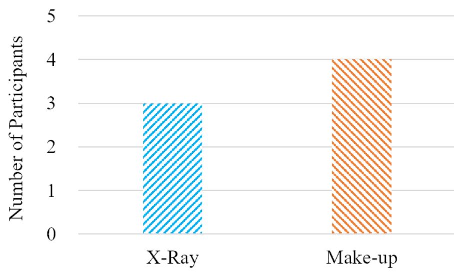
[1]https://unity.com/

4 EVALUATION

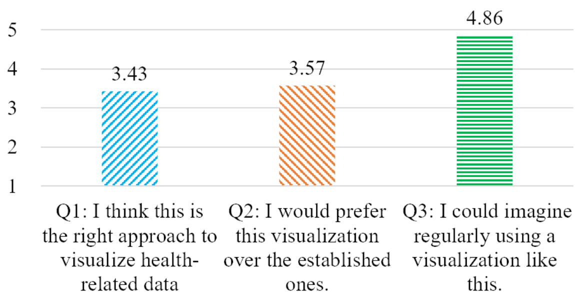
We conducted one pilot study for each use case. For both studies, we recruited paid participants via email announcements. At the beginning, we asked the participants to fill out a questionnaire to collect demographic information, as well as prior experience with AR and fitness trackers. We provided them with instructions on how to install and use our app prototype. If required, we provided the necessary hardware for the duration of the study. After the studies were completed, the participants took part in an audio-recorded semi-structured interview. We asked them about their experiences, insights and suggestions for improvement. The guiding questions included three Likert scale questions, where 5 means "strongly agree" and 1 means "strongly disagree":

- **Q1:** I think this is the right approach to visualizing health-related data.
- **Q2:** I would prefer this visualization over the established visualization I am currently used to.
- **Q3:** If done right, I could imagine using a visualization like this on a regular basis.

We conducted a visual analysis of the collected data and clustered participants' statements from the interviews with similar content to identify core themes. We then sorted the qualitative results by the categories: *technology feedback, design feedback,* and *general feedback*.



(a) Preferred data representation



(b) Subjective Likert scale

Figure 3: The results of the five-day study for historic comparison: (a) more participants preferred *Make-up* than *X-Ray* and (b) the average scores of subjective feedback.

In the following, we describe details distinct to each study and their results.

4.1 Study I: Historic Comparison

We recruited 7 paid participants (5F/2M, 26–35 years, marked as P1–P7) who had previous experience using fitness trackers. We instructed them to set their individual goals (steps and sleep per day) in the app. They then updated the data in the app and looked at the AR visualizations at least once per day over the course of five consecutive days. Afterward, we conducted a semi-structured interview with the participant.

4.1.1 Technology Feedback. All participants indicated that the app provided useful insights into their daily activity (steps) and sleep in relation to the goals set by themselves. 2 participants mentioned that it made them feel more aware of their body health. The mean scores on the Likert scales (see Fig. 3b) indicate that there is no strong tendency to accept or reject the AR approach (in its current form) in lieu of traditional fitness tracker visualizations, 3 participants stated that they would opt to use both. However, participants strongly agreed to using this type of visualization regularly if it met their expectations. One participant also expressed that they would use the AR visualization immediately if it were already available in a consumer-oriented app.

Participants stated that the AR visualization in our app is more fun and interesting, and that it provides a fast and easy overview of the data. Participants also said that this had a positive effect on their motivation. One participant emphasized that they can identify with the data better when they see it on their face than when they see only it on a screen. However, participants also noted that accessing the data through the selfie camera filter requires more effort and time: *"I always have to look at myself in the camera and can't squint at it briefly on the side." (P3).* In addition, participants mention the app's lack on detailed information and graphs which can be found in other health apps. That's why participants suggested using both types of visualization.

4.1.2 Design Feedback. When comparing the two designs, each participant indicated a clear preference for one of the two designs, but there was no general agreement on which was better (see Fig. 3a). Participants found *Make-Up* to be more rewarding: *"I was motivated by the golden dot. I'm not that interested in the numbers. But at the end of the day, I really wanted that golden dot!" (P4).* Participants also liked that they could see values for each day and compare their performance over the course of the week. On the other hand, participants criticized a) the position of the visualization, as one had to turn one's head to read the data and long hair could obscure it, and b) that it required more effort to understand the visualization in the way that the data was represented. Participants found this filter design to be more aesthetically pleasing than *X-Ray*, but some stated that it does not fit their personal taste.

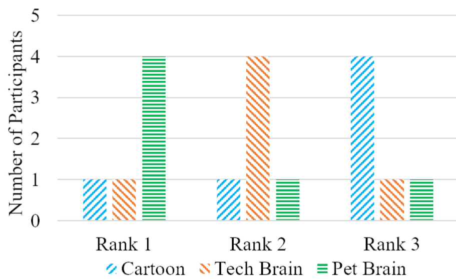
Even though the aggregated data representation of *X-Ray* did not provide statistical insights, participants found it easier and faster to understand. Participants praised the usefulness of the speech bubble, which provided clear instructions and/or feedback on their performance. One participant considered the visualization of the brain to be creepy or uncanny, whereas another participant stated: *"I really enjoyed being able to see that I do have a brain." (P13).*

4.1.3 General Feedback. The majority of participants indicated that, unlike opening a selfie camera app on a smartphone, AR visualization would benefit from an effortless access mode, such as if it were built into the bathroom mirror or their everyday prescription glasses, in the form of an interaction-free ambient visualization. In addition, participants called for customization options, such as different *Make-Up* designs to better suit individual preferences. They also suggested showing the visualization on other body parts, e.g., arms or hands, instead of the face.

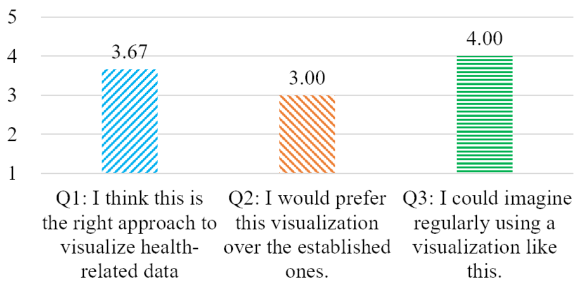
4.2 Study II: Self-Reflection

For the second study, we recruited 6 paid participants (4F/2M, 26–35 years, P8–P13) who also had previous experience using fitness trackers or other forms of personal quantification. We checked the participants' fitness trackers and entered their values for current heart rate, stress level, and sleep duration from the previous night into the app. When data on sleep duration were not available, an estimate was made based on the information provided by the participants. They then launched the AR visualization and viewed the different filter designs. We also encouraged participants to play with different input values and combinations, simulating more scenarios.

4.2.1 Technology Feedback. In general, the results were similar to *Study I.* Participants indicated that they could quickly and easily see what was wrong with themselves. Participants indicated that they understood the data and were able to draw conclusions about



(a) Ranking of Data Representations



(b) Subjective Likert scale

Figure 4: The results of the momentary study: (a) *Pet Brain* was the most favored design while *Cartoon* was the least favored and (b) the average scores of subjective feedback.

the impact it had on their own bodies: *"Seeing your own face helps making a connection between the data and yourself." (P8)* and *"I got an insight into how my brain might feel if I don't give it what it needs." (P10)*. In this use case, the majority of participants showed a slightly higher acceptance of our visualization (Q1), as shown in Fig. 4b. When asked whether they would prefer this visualization over the one they were already familiar with (Q2), again, the feedback was mixed. Two participants agreed because *"Pet Brain is just so cute." (P12, P13)*. Participants again expressed concerns about accessing the AR visualizations on the go and stated similar reasons and implications as participants did in *Study I*. Similarly, the majority agreed to use the full version of our visualization regularly (Q3).

4.2.2 Design Feedback. Overall, the *Pet Brain* was popular among participants due to its playfulness and use of emotion and empathy to elicit motivation. When asked to rank the filter designs, there seems to be some agreement that *Pet Brain* ranks first, *Tech Brain* ranks second, and *Cartoon* ranks last (Fig. 4a). 3 participants found *Pet Brain* to be appealing, cute, and fun. 2 of them indicated that when they saw the sad *Pet Brain*, they would feel strongly motivated by the urge to make it happy. Participants said that the primary reason for *Tech Brain* to rank second was that it was the easiest to understand, even though less "fun". As for *Cartoon*, 2 participants thought the changes to their faces to be *"creepy"* or *"ugly"*. 3 participants stated that they found it difficult to read. However, one participant recognized its potential use in assessing individual health status in groups, e.g., as a tool for fitness instructors.

4.2.3 General Feedback. In general, 4 of 6 participants noted that they liked the gamification aspect and the idea of integrating a visualization like this into a mirror for effortless interaction. In addition, 3 participants indicated that they would be interested in *Pet Brain* as a standalone visualization, even without AR. Again, participants said that the AR visualization could be further improved by showing graphs and statistics on demand, e.g., by implementing a button for more detailed information.

5 DISCUSSION

We aim to improve our understanding of the design space of using AR for visualizing fitness. Based on the feedback from our pilot studies, we were able to make the following main observations:

AR poses a novel approach that can add to current visualizations. Participants liked the novelty and fun factor of our approach. Most users indicated that they would prefer having both: on-body visualization for the emotional, fun, and aesthetic aspects, and a traditional 2D visualization (e.g., on a smartphone) for detailed and accurate statistics on demand. This shows that our proposed visualization does not necessarily replace the prevailing visualizations, but rather can be a useful addition in the context of personal quantification.

Ambient visualization needs to be further explored. AR visualization on mobile devices lacks the "glanceability" of smartwatches and requires more effort, which would make them even more likely to be abandoned. Therefore, we propose using our visualization in an ambient setup, e.g., integrating it into the bathroom mirror—building upon research in ambient visualization [13, 15]. This could make the visualization of health data an integral part of daily life without much effort. We hypothesize that like this it would be much more difficult to abandon personal quantification compared to wearables and dedicated health apps.

Emotional and playful approaches to health data resonate with users. In our study, participants preferred data visualizations that evoked emotion, playfulness, or aesthetic satisfaction more than objective representations of data values, as long as the data could still be clearly interpreted. This finding echoes aspects of personal and ambient visualization [8, 13].

Empathy can create strong intrinsic motivation. In our study, we anthropomorphized user health as a *Pet Brain*. Participants seemed to feel more empathy for the pet brain than for themselves. They reported strong motivation to "make the *Pet Brain* feel better". To avoid alienation, AR could be the factor that links this empathy back to the users' bodies.

Visualizing fitness tracker data in the visual context of the body can raise awareness of its impact on personal health. We found that through the use of AR, participants perceived their personal health data differently—not just as numbers detached from the body, but rather as something connected to it. As participants have reported, this could have a major influence on users' intrinsic motivation and health awareness. On this basis, further methods could be developed to also improve health literacy.

Aesthetics play an important role. In our approach, we directed participants' attention to visual changes on their faces, an area of the body that has a strong influence on body image and beauty. This has strong implications on design considerations. Participants noted that one way to address user needs is to offer customization and different design options. Moreover, a large group of users might find the visualization of internal organs visually unappealing. This effect might be reduced by using a more cartoonish style.

AR could be a way of sharing health data with others. Just like "AR selfies" which get shared on social media, AR could play a role in how we communicate personal health towards others. As one participant noted, it could be a helpful tool for fitness instructors, but also doctors, and others. In this approach, privacy and active user consent play an important role, as well as the discussion of what impact the sharing of this information may have on social interaction.

6 LIMITATIONS AND FUTURE WORK

The major limitations of our results stem from the small size of the pilot studies. While we cannot derive generalizable conclusions from such exploratory studies, they provide us with indicators and potential starting point for future work on the subject. Our main goal was to start this process by exploring ideas, opportunities, and challenges in this novel design space. A particular limitation of our results is observing the motivational impact of our visualizations based on participants' self-reported perceptions or expectations. Self-reporting can differ greatly from the actual long-term motivation and outcome. In the future, we want to test these aspects in a long-term study.

We identified two major directions in which we plan to continue our research. On the one hand, we want to investigate the AR visualization of fitness tracker data in an ambient mirror setup and run a confirmatory study on hypotheses derived from our preliminary results presented here. For this, we will also refine the visualization designs based on our participants' feedback. On the other hand, we feel that AR could be a valuable tool for sharing and communicating personal health data with others. Our pilot studies have barely covered this potential, which is why we want to conduct further research in this direction.

7 CONCLUSION

Fitness tracker use and personal quantification are already becoming increasingly important. There is a growing body of work on its potential to improve public health and health awareness. Given the potential benefits, we wanted to initiate a discussion about adopting AR as a new approach to visualizing fitness tracker data. To that end, we discussed results from two pilot studies, contributing to the understanding of the potentials, challenges, and design space. This discussion gives directions to future work on the subject.

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