

Exploring Artistic Data Visualization Design for Health Monitoring: A Survey Study

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Abstract. As the global population ages, there is an increasing need for innovative approaches to support healthy aging and independent living. Remote measurement technologies (RMTs) offer promising solutions but face challenges in user engagement and sustained utilization. Addressing these challenges requires effective visualization of health data to promote comprehension and sustained engagement. In this study, we proposed an artistic approach to health data visualization and conducted a survey involving 8 participants (3 individuals and 5 informal caregivers) to explore their preferences and needs in this regard. Two preliminary artistic visualization concepts were presented, eliciting feedback to inform design considerations. Findings underscore the importance of prioritizing aesthetics, ensuring comprehensibility, balancing information presentation, and seamlessly integrating visualizations into users' daily routines. Based on these findings, we present four design considerations to guide future research efforts and contribute to the development of artistic visualizations supporting health monitoring.

Keywords: Health monitoring · Data visualization · Art.

1 Introduction

The global population is aging rapidly, with projections indicating that by 2050, the number of individuals aged 65 or older will reach 1.5 billion [1]. This demographic shift poses challenges for the healthcare industry, leading to a rise in healthcare utilization and associated costs [2, 3]. In response, promoting self-management and providing elderly individuals with the necessary tools and support to live independently becomes crucial. Informal caregivers, typically family members or close friends, play a vital role in supporting self-management efforts by providing emotional support, monitoring health data, and assisting with daily activities [4].

In recent years, there has been a growing focus on technology as a means of supporting healthy and independent aging, with remote measurement technologies (RMTs) emerging as a promising solution [5, 6]. RMTs assist in delivering or facilitating support for both individuals and caregivers, offering a range of benefits in healthcare management, including various (mobile) health devices and applications that allow for health data monitoring [6]. Despite their benefits,

challenges persist regarding user engagement and long-term utilization. Studies indicate that approximately one-third of devices are abandoned within six to twelve months of use [7]. Specifically, research shows that 50% of Fitbit users abandon the device within the first two weeks of use [8], and around two-thirds of users of RMTs quit using within several weeks to six months of purchase [9].

Moreover, making sense of health monitoring data retrieved from RMTs creates demands for turning data points and trends into actionable insights [10]. Data visualization emerges as a crucial tool in this process, intuitively communicating complex information by harnessing the human visual capacity to perceive differences in size, color, and spatial position [11, ?]. Such visual representation not only enhances understanding but also empowers users to make informed decisions about health and well-being. However, current visualizations of health data in common health-tracking applications often rely on conventional forms such as bar charts, pie charts, scatterplots, and tables [13]. These visualizations mainly focus on triggering a single intended behavior, such as physical activity, rather than promoting review and understanding of the health data itself [14]. Additionally, certain types of conventional visualization, such as pie charts and area-based graphs, can be confusing and require significant time to interpret accurately [15]. This poses challenges, particularly for users lacking in health literacy, who may struggle to understand such visualizations effectively [16]

Recognizing the opportunity to develop visualizations that not only effectively convey information but also foster sustained engagement with health data over time, we propose an artistic approach to visualizing health data. A survey study was conducted involving 8 participants (comprising 3 individuals and 5 informal caregivers), during which we presented two preliminary artistic visualization ideas. The aim of this survey was to investigate the needs and preferences of individuals and informal caregivers regarding health data visualization in the current context of RMTs and to collect feedback on the proposed artistic approach. The findings contribute to identifying four key design considerations for informing subsequent research endeavors and providing insights for the development of artistic visualizations that support health monitoring.

2 Methods

2.1 Inclusion Criteria

This study comprised two participant groups: individuals and informal caregivers. Eligible participants were adults aged 18 years or older. For individuals, inclusion criteria were current or previous use of at least one of RMTs for health data tracking. For informal caregivers, inclusion criteria included: (1) being a caregiver for a “dependent person” or “care recipient,” providing unpaid care, and (2) current or previous use of at least one of the RMTs for tracking the health data of the person under their care.

2.2 Sampling and Recruitment

A purposive convenience-based sampling was used to recruit participants who met the aforementioned criteria. Two approaches were used for recruitment: individuals were recruited from the researcher’s network of contacts, while informal caregivers were recruited through Hangzhou Bobo Technology Limited Company (referred to as Hangzhou Bobo). Hangzhou Bobo is a company specializing in intelligent healthcare solutions, utilizing mobile internet technology to address issues such as chronic disease management. Hangzhou Bobo appointed a coordinator who contacted potential participants from customers of Slaap Lekker¹. Slaap Lekker is a smart sleep and health monitor that monitors health data from the user’s vital signs during sleep. Those who provided voluntary informed consent were formally enrolled in the study. This study received ethical approval from the Ethics team of the Eindhoven University of Technology (TU/e). Participation in the study was voluntary.

2.3 Preliminary Design

Two preliminary visualization ideas were created for stimulating discussion and eliciting feedback. Design A utilized pixelated artwork, where the whole image represented the health status through the gradual greying of pixels as the health status deteriorated. The complete pixel artwork indicated optimal health, while the increasing number of gray pixels represented a decline in health (Fig. 1).

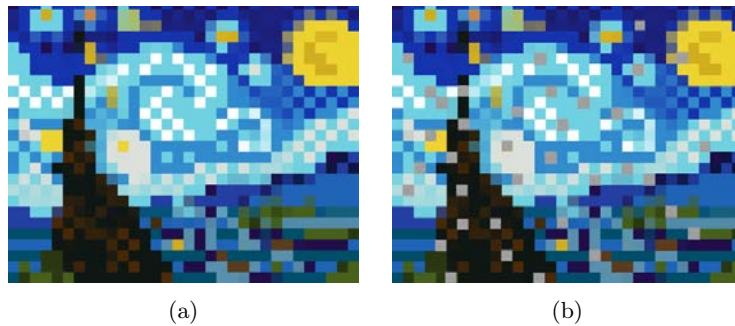


Fig. 1: Design A: (a) Complete pixel artwork depicting optimal health status; (b) Pixel artwork with added gray pixels indicating deteriorating health. The artwork is based on Van Gogh’s “Starry Night”.

Design B utilized a more targeted approach by incorporating shapes and colors to visualize specific health indicators. Borromean rings (Fig. 2) were used as a metaphor for overall health. Each ring represents a different health indicator, such as heart rate, blood oxygen level, and breathing rate. When all the

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indicators fell within the healthy range, the rings were fully interlocked. If any index exceeded the healthy range, the corresponding ring became disconnected, indicating a suboptimal or bad health status.

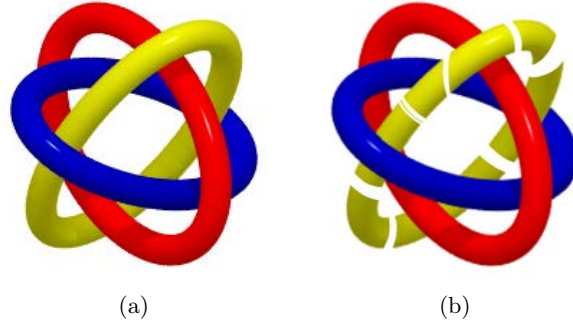


Fig. 2: Design B: (a) Complete Borromean Rings with all health indices within healthy ranges; (b) Broken Borromean Rings with the yellow ring indicating a health index outside the healthy range.

2.4 Survey Study

A survey was developed to collect qualitative data from individuals and informal caregivers. The survey questions were essentially the same for both groups, with minor adjustments to accommodate their different contexts. The data collection methods varied based on the group. For individuals, the survey was administered through face-to-face interviews (in English) conducted by the first author, who served as the interviewer. For informal caregivers, a paper-based survey was provided in Chinese, allowing them to answer in their native language. The coordinator delivered and collected the surveys from informal caregivers and then sent completed surveys back to the researcher as digital scans.

Content of the survey. The survey was structured into three sections: (1) user experience with RMT(s), (2) user experience with health data visualization and suggestions on improvement, and (3) collection of insights into the initial visualization design ideas. Demographic information was collected from participants at the beginning of the survey.

The first section consisted of six questions, covering the duration of use of RMT(s), frequency of examining health data through RMT(s), potential changes in user behavior over time, perception of the health data, specific information sought during the data review, and whether using RMT(s) helped support the health tracking/management.

The second section comprised nine questions that began with asking about participants' experience with health data visualization tools. It further delved into challenges encountered in tracking health data, the impact of visualization in this process, and how it compared to the guidance or support provided by formal healthcare providers. Participants were also asked about their preferences or requirements for health data visualization, including desired features or functionality.

In the final section, participants were shown the two preliminary design ideas, with an explanation of the difference between conventional form data visualization and unconventional form data visualization. They were then asked to share their thoughts on the design ideas. All terminology mentioned in the survey was clearly explained to participants before or during the survey.

3 Results

Sample Characteristics A total of 8 participants attended this study, including 3 individuals (I1 to I3) and 5 informal caregivers (IC1 to IC5). Their characteristics are summarized in Table 1.

Table 1: Demographic characteristics

Characteristic	Individuals (n=3)	Informal caregivers (n=5)
Age (years), n (%)		
≤ 30	3 (100)	2 (40)
31 - 40		1 (20)
41 - 50		1 (20)
> 50		1 (20)
Gender		
Male: Female	2:1	2:3
Residence, n (%)		
the Netherlands	2 (66.7)	
China	1 (33.3)	5 (100)
Highest education completed, n (%)		
High school		2 (40)
Bachelor's degree		3 (60)
Graduate degree	3 (100)	
Duration of using RMTs (years), n (%)		
≤ 1	1 (33.3)	4 (80)
1 - 3	2 (66.7)	1 (20)
Duration of caregiving (years), n (%)	Not applicable	
≤ 1		4 (80)
1 - 3		1 (20)
Type of caregiving	Not applicable	
Parent		5 (100)

User Experience with RMTs

Impact on health management. There was a general view among the participants that RMTs helped them promote self-awareness and support health management by providing them with convenient and timely health data updating. Moreover, informal caregivers reported that RMTs enabled more effective communication with their care recipients since information can be transmitted at any time, which further improved their relationship and emotional well-being. However, participants also expressed an expectation to see more information beyond the data itself, such as information on the overall health condition, which is currently lacking in existing RMTs. They also suggested that RMTs should be more personalized and interactive, and provide more feedback and guidance on how to improve their health outcomes.

Changes in usage over time. Most participants reported reduced frequency in checking their own health data or that of their care recipients compared to when they initially began using RMTs. This could be attributed to reduced interest, as they did not find the data to be valuable in providing useful insights, as one individual stated: “I don’t understand what they mean [...] I lost my interest to viewing them without not getting much valuable information.” [I3]

Another factor that contributed to reduced checking frequency related to the informal caregivers was an improved understanding of the data. Some of them who gained a better understanding of the data during the usage period reported a reduced concern for minor fluctuations in the health data over time: “I learned the corresponding explanation of the data later, I would not be too entangled in the small changes in the data.” [IC1]

However, for some individuals, the frequency of using RMTs remained relatively stable over time. Those who relied on RMTs to track their fitness data reported that their continued use was driven by the need to track their physical activities.

Emotional impact. Several participants expressed concerns about the reliability of RMTs, leading to a lack of trust in the health data they provide. Apart from the doubt about the technologies, the lack of clarity between data and user performance was also a major contributor to this concern. One individual reported feeling anxious while using RMTs: “Sometimes it even caused me anxiety since some indexes can be abnormal all the time, which makes me very worried [...]” [I2] These negative emotional experiences can have a significant impact on the user’s mental health. Therefore, it is necessary to consider the emotional impact of RMTs and design them to deliver information in a more user-friendly manner.

Health Data

Dissatisfaction with raw data and preference for information. While most participants acknowledged the importance of health data, they expressed their dissatisfaction and uncertainty about raw health data. This was especially reported

by informal caregiver participants, who lacked professional training and familiarity with basic health terminologies and analysis. Due to the high demand for health-related knowledge in caregiving tasks, some of them have even resorted to seeking interpretation and meaning of the data online. They, therefore, have expressed a desire for a clear picture of how good or bad the health condition was along with some analysis and explanation, which matches the user experience mentioned earlier with RMTs. Moreover, healthy individuals among the participants have expressed strong disinterest in knowing about specific health data. Instead, they have expressed a preference for general information regarding their health and the option to check specific data only when they want to. As one individual noted: “[...] most of the time it can be a general information but if I want to know the specific data I can also find it somewhere.” [I2]

Desire for actionable insights. Participants expressed a desire for specific and understandable recommendations on how to use health data to make better health management decisions. They expressed concern about the actions or steps they should take based on the health information they received.

Health Data Visualization

Meaningful visualization of health data. Participants reported that while visualizing health data in a different format (e.g., graphs) seems straightforward, it may not be helpful. Different formats did not add any value if the user did not understand the meaning behind the data. Therefore, participants expressed a desire to see an overview of their overall health status rather than numerous bar charts showing different health data. This opinion was evident in their responses to the question about the missing features in the current health tracking devices and visualization tools.

Simplicity, aesthetics, and balance. Participants emphasized the importance of simplicity in health data visualization as it could contribute to better comprehension. Videos and animations were highly mentioned as potential approaches to visualize health data more engagingly and interactively. While most participants did not provide specific suggestions for making health data more userfriendly, many expressed a desire for visualizations to be beautiful, suggesting that aesthetics play an important role in their preferences for health data visualization. Interestingly, one informal caregiver specifically mentioned the wish for “a combination of digital and abstract, pictorial representations” [IC5], which aligns with the idea of providing a general overview of health status along with specific data as needed. This highlights the importance of striking a balance between the big picture and detailed information.

Insights into the Preliminary Design Ideas Participants had mixed opinions on Design A and Design B. Design A was praised for its novelty and creativity, but some participants expressed concerns about the clarity and effectiveness

of using pixel art to represent health data. For instance, one participant stated that said that the pixel artwork might be too blurry or low-resolution to convey health information. Another participant questioned whether the pixel variations would be noticeable enough to draw the user’s attention. Design B was appreciated for its simplicity and straightforwardness ins using simple shapes and colors to convey the health data effectively. However, it faced criticism regarding its visual appeal, as it was perceived as lacking in aesthetics. Moreover, one participant was puzzled about how the three health data were selected over other health indexes and presented in three rings.

4 Findings

The results highlight the need to refine data visualization used in RMTs. While acknowledging the positive aspects of RMTs, the findings reveal shortcomings that require further research.

Current data visualizations in RMTs, such as bar and line graphs, are perceived as lacking meaningful insights by participants, leading to a decline in interest in health data over time. This indicates a clear gap between the value of health data and users’ perceived usefulness, where conventional visualizations fail to support users’ ability to derive meaningful insights from the data.

Informal caregivers lacking professional training and familiarity with basic health terminologies and analysis expressed incomprehension and uncertainty when faced with raw health data. They sought interpretations, analyses, and explanations accompanying the health data. On the other hand, healthy individuals expressed disinterest in specific health data and preferred general health information as it related to their overall health outcomes and well-being. These findings suggest a need for a flexible design approach that can address the diverse requirements and accommodate the varying needs of different user groups.

Additionally, participants emphasized the importance of aesthetics and suggested the use of dynamic presentations, to engage users. This coincides with the growing recognition of the critical role that aesthetics play in engaging users and facilitating meaningful interactions with health data (Sutcliffe, 2009). However, it is important to strike a balance between artistic expression and conveying meaningful information. A well-executed visualization should harmonize visual appeal with the ability to communicate health knowledge in an understandable manner.

Moreover, the emotional impact caused by RMTs was a significant topic among participants, as concerns about the reliability of the provided health data led to a lack of trust, or the overwhelming focus on health data sometimes led to negative emotional experiences, including feelings of anxiety and annoyance. Such negative emotional responses can potentially diminish one’s motivation to seek health information and, therefore, lead users to disengage from RMTs during periods of disease relapse or noticeable progression (Lee et al., 2008). Thus, addressing these emotional concerns and designing RMTs to deliver informa-

tion in a pleasing and user-friendly manner is important to promote positive emotional experiences.

5 Design Considerations

Based on the findings, we have established four design considerations:

C1 Emphasize Aesthetics: The visualization should prioritize the incorporation of visually appealing elements that captivate users and deliver health information in a userfriendly manner to promote positive emotional experiences. Consider using color, shape, and other artistic elements to evoke interest and convey health information effectively.

C2 Comprehensibility: The visualization should strive to convey health information in an understandable manner. The visualization should not sacrifice clarity for aesthetics, ensuring that users can easily interpret the presented visuals. Avoid the use of complex metaphors.

C3 Balance of information: The visualization should balance general information with specific details, ensuring that users can quickly grasp the key insights while also allowing them to dive deeper into more specific details if needed. Provide visualizations that offer a comprehensive overview of users' overall health status, addressing the preference for collective health data rather than relying solely on conventional forms like bar or line graphs.

C4 Seamless integration into daily routines: The visualization should be designed in a way that seamlessly integrates with users' routines. This can be achieved by considering factors such as simplicity, convenience, and compatibility with existing technologies or devices commonly used in daily activities. By integrating visualizations seamlessly, users can effortlessly access and engage with health information without disruptions, ensuring a harmonious coexistence with their regular routines.

6 Conclusion

This study reveals the need for innovative data visualization strategies for health tracking/management purposes. Although precise design opinions for artistic and abstract data visualization were not extracted in this study, common aspects emerged, including providing a comprehensive overview of health information, addressing emotional implications, incorporating aesthetics, and ensuring consideration of the diverse needs of different stakeholders. The proposed design considerations provide valuable insights for the development of future artistic visualizations in the realm of health monitoring and self-management. By emphasizing aesthetics, comprehensibility, information balance, and seamless integration, designers can create visualizations that not only captivate users but also empower them to make informed decisions about their health and well-being.

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