
Your Body of Water: A Display that Visualizes Aesthetic Heart Rate Data from a 3D Camera



Figure 1: *Your Body of Water* aesthetically visualizes a visitor's heart rate from a 3D camera.

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Abstract

We present the design and implementation of *Your Body of Water*, a display that wirelessly gathers heart rate data using a 3D camera and then visualizes the viewer's heart rate as water. As heart rate goes up the water gets livelier (with larger and faster waves) and as heart rate goes down the water gets calmer. The purpose of the display is to use aesthetic biofeedback data to help participants reflect on their felt bodily experience. The device went through system critique using somaesthetic appreciation design heuristics, and we describe the design themes that arose from those critiques.

Author Keywords

Biofeedback; Heart Rate; Pulse; Somaesthetics; Heuristic Evaluation; Display; Visualization; Information Visualization; Embodiment; Aesthetics

ACM Classification Keywords

- Human-centered computing~User studies

Introduction

In this study, we explored whether wireless heart rate sensors could encourage embodied somaesthetic introspection (Figure 1). By reading heart rate wirelessly we hoped to encourage participants to reflect

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Somaesthetics: an interdisciplinary field with roots in philosophy that combines the soma (the living body) with aesthetics (our sensory perception)[2].

Somaesthetic Appreciation Design Characteristics[3]

Subtle Guidance: The design's ability to subtly and slowly direct a participant's attention inward.

Making Space: The design's ability to create both temporal and physical space within a participant's day for self-reflection.

Intimate Correspondence: How closely the interaction follows how the participant is feeling and what they are experiencing.

Articulation: The design's ability to give participants a way to articulate how they are feeling, as well as to make sense of their experience.

on how they are feeling, rather than focusing on their heart rate. This artwork display uses water as an aesthetic and calming way of visualizing real-time biofeedback data and aims to show how heart rate can help participants reflect on their experience and felt bodily states. The artwork aims to respond to how the user is feeling, but at the same time gives room for participant's subjective interpretation and to reflect on their own experience.

Theoretical Grounding: Design for Somaesthetic Experience

In this research project, we used somaesthetic philosophy to design a display that responds to heart rate and aims to help viewers get more in touch with their body. The main premise of somaesthetics is that we can train our body to become more aware of itself. Somaesthetics explores how we can improve and cultivate our senses through a better understanding of our sensory appreciation (*aesthesis*) [2].

This project is inspired by a psychophysical model of the body where our thoughts influence our body and focuses on how heart rate is connected to our emotional response. For example, much research has been done on how heart rate increases when humans feel stressed or excited, and how it lowers when one is calm. Slovak et al [10] have also shown that participants interpret heart rate as signaling emotional state.

In their paper "Somaesthetic design", Hook et al [2] discuss how they translated somaesthetic theory into practice. The main goal of somaesthetics in design is to create devices and systems that encourage participants to look inward and focus on their own bodily sensations

rather than external stimuli [2]. In terms of how to design for somaesthetic experience, they developed somaesthetic appreciation design characteristics[3].

The four characteristics of somaesthetic appreciation design include **subtle guidance** in how they encourage bodily inquiry, **making space** by shutting out the outer world and encouraging inward focus, **intimate correspondence** in how the feedback follows the rhythms of the body, and **articulation** in how the design helps participants understand, learn, and become more aware of their bodies and lived experience[3].

Contributions

This paper contributes a heuristic evaluation, using somaesthetic appreciation design characteristics and system critiques, of a display that aesthetically visualizes heart rate data from a 3D camera. This paper is the first to evaluate an aesthetic display that gathers heart rate with a 3D camera.

Related Work: Aesthetic Heart Rate Artworks

Sun et al. [11] looked at the different ways that heart rate biofeedback can be visualized: graphical, illustrative, artistic, and ambient. They found that the metaphors in artistic and ambient displays helped viewers make a connection between themselves and what they saw, and created a "deeper impression".

Previous research in the area of aesthetic heart rate biofeedback has included projects such as CubeLife[1] Cardiomorphologies[6], LivingSurface [14], Heart Calligraphy [13], Metaphone[9], and StressTree[15]. Each of these projects mapped heart rate to aesthetic



Figure 2: The Intel RealSense camera sitting on top of the display.

visuals. These projects have demonstrated the importance of real-time feedback, accurate sensors, room for reflection and environment to aestheticized heart rate visualizations. Among the biofeedback artworks that visualize aesthetic heart rate data, most of them gather pulse from the hand, and the Arduino pulse sensor[7], which attaches to an individual's index finger. During each of these projects participants were tethered to the device and in doing so the design itself signaled that it was reading heart rate.

Prototype: *Your Body of Water*

For this display, we wanted to evaluate the somaesthetic appreciation design characteristics of a display that gathers heart rate wirelessly with a 3D camera. During initial prototyping with the Intel RealSense 3D camera[4], we found that the device could gather an accurate heart rate reading while participants were moving, when they were turned to the side, and even when their face was partially covered. Gathering heart rate wirelessly is part of the Intel RealSense software development kit (SDK). For this project, we placed the camera on top of a large display that visualized the data (Figure 2).

The water simulation was purchased on Unity[12], and we programmed the measures of wave height, wave speed, wind speed, and foam to all gradually increase and decrease as heart rate increased or decreased (Figure 3).

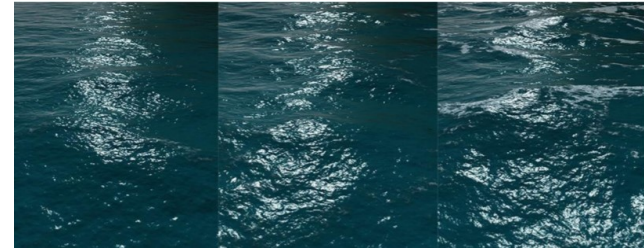


Figure 3: Changes in the water as heart rate goes up.

Method: Heuristic Evaluation with Somaesthetic Design Characteristics

For the evaluation of interactive artworks, Hook et al[3] recommend using "system critics". Similar to how art criticism has a culture of experts doing art critiques, the system critique would involve interaction designers who can evaluate a system using their background knowledge. These types of system critiques have been useful for discovering and identifying problematic areas of an interaction as well as for discussing possibilities for improvements to the work[5]. As a result, we used system critique using somaesthetic appreciation design characteristics.

To implement this evaluation method, we had individual critique sessions with 10 graduate students studying interaction design. For each of these sessions, a participant got to use the system for as long as they liked while being asked for their informed critique of the work based on the somaesthetic design characteristics. The first author gave each participant a sheet with the definitions of each of the characteristics, and briefed the participant on each one. Participants wrote down and discussed their critiques and the first author also took notes.



Figure 4: *Your Body of Water* display set up.

Results

Subtle Guidance: Subtle guidance is the design's ability to subtly direct a participant's attention inward. During the system critique sessions participants noted that the interaction was subtle, but at times too subtle. Participants stated that at times they decided to explore the work by jumping up and down, or thinking about uncomfortable thoughts, and at these times expected the water to be really stormy, but instead only noticed subtle changes in the water.

Making space: Making space is the design's ability to create both temporal and physical space within a participant's day for self-reflection. Every system critic involved said that this characteristic was met. Some said that the soothing imagery acted as a reminder to relax and reflect, and some mentioned that by simply having an object like this in one's home they would be more inclined to reflect on how they are feeling (Figure 4). Seven system critics mentioned locations either within the home, or in offices, where it would be useful to place an object like this to encourage reflection.

Intimate Correspondence: Intimate correspondence is how closely the interaction follows how the participant is feeling and what they are experiencing. This is where the accuracy of the sensors and how the responding visualizations aesthetically represent the data becomes important. In the critique sessions, the characteristic of intimate correspondence was only met to a certain extent. As mentioned in the critique of subtle guidance, the visualization changes were thought to be too subtle. A few participants explored how they could raise their heart rate, but the changes in the water did not seem to reflect their exertion or stress level. All participants discussed the display in

relation to how they were feeling, suggesting that the display encouraged them to reflect on emotional and physical state rather than heart rate alone.

Participants also wanted an explicit sign as to whether the device was reading them or not. Since the water was always moving, participants had some difficulty differentiating when the device was not reading them and when the water was calm (a low heart rate).

Articulation: Somaesthetic articulation means to create responses that support bodily reflection. It gives participants a way to articulate how they are feeling, as well as to make sense of their experience. All participants found the choice of water to be an effective visual for thinking about how they were feeling. Participants described the water as soothing and an apt metaphor for states of feeling. Participants understood how water moves, and the concept of it getting livelier or stormier as heart rate went up was a metaphor that made sense.

Discussion

Using somaesthetic design appreciation characteristics in system critiques was an effective way of finding problematic areas in the interaction as well as for discussions on how the display could be improved. The main issues that impeded somaesthetic reflection included the subtlety of the water and the inability to differentiate when the system was picking up (or reading) a participant's heart rate.

One of the major challenges was designing the display so that the changes in the state were both subtle and recognizable. Based on the system critiques the visualization was programmed to show more dramatic

changes in wave height, wave speed, wind speed and amount of foam.

The second issue with the display demonstrates some of the new challenges that arise when using wireless sensors. Participant wanted to know when they were being “read” by the wireless camera. At times participants found it difficult to recognize when the camera was reading them and when they went out of range. As a result, system critics suggested using an on/off visualization in the water so that participants could immediately recognize when they were being read by the sensor. Several system critics suggested changing the environmental lighting from night to day when a participant was in range (Figure 5). This is similar to how a computer goes into sleep mode when not being used.

Another issue this brings up is gathering data and consent. When someone puts on a pulse sensor there is implicit consent that by putting it on they know it will gather their heart rate. With wireless sensors there isn’t this opportunity. Researchers looking at large displays, such as Rodriguez et al [8], have begun to look at how users can signal consent with large displays, but research is still in early stages. As a result, for this project the program didn’t save any data, but this is an important area for future research.

Finally, participants suggested several locations that they thought would be useful environments to have moments of reflection. These included waiting rooms, lobbies, and when you enter or exit your home. Our next steps include *in situ* testing of the work in these locations.



Figure 5: The display signaling when it is reading a participant by going from night to day

In the Wild Evaluation and Exhibition

After the system critique sessions, suggested alterations were made to the display, it received a final group critique, and was shown to the public in a one-week exhibit. These iterative changes mentioned in the discussion, (more dramatic changes in the waves and a sleep mode when the sensor is not reading a participant) were both well received during the critique and week-long exhibition.

Conclusion

We presented the design and initial heuristic evaluation of an ambient display that aesthetically visualized heart rate data as gathered from a wireless sensor. Though participants focused on how they were feeling and their bodily state rather than heart rate alone, our heuristic evaluation stressed the importance of showing when a participant was being read by the sensor, as well as other issues of consent when using wireless sensors.

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