Crimson Wave: Shedding Light on Menstrual Health

Figure 1. The Crimson Wave smart mirror.

Figure 2. The user's sensor registers a BBT that is higher than is normal, and the smart mirror calculates that they are on their period, causing the LED lights to shine red.

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Abstract

Crimson Wave is a personal tangible user interface that generates and displays information about its user's menstrual cycle. Basal Body Temperature (BBT) is an individual's temperature at rest, which fluctuates menstruation. Crimson Wave tracks the user's BBT through the wearable armband and then displays the data visually on a separate smart mirror. Specifically, the mirror lights up a corresponding color depending upon the menstrual stage the user is experiencing. Crimson Wave offers a novel method of keeping track of one's health and integrating one's own menstrual information seamlessly into daily life. The combination of live and aggregated personalized data helps users optimize their day to day life. Crimson Wave is helpful to people who are interested in being more informed about their cycles, especially when they are irregular. In this paper, we describe the concept behind Crimson Wave, as well as its implementation and iterations.

Author Keywords

Tangible interaction; physiological sensor; menstruation; wearables

ACM Classification Keywords

Human-centered computing~User interface design

General Terms

Design, Human Factors, Health

Figure 3. The user's sensor registers a BBT that has dropped from a high of around 37° Celsius. The mirror thus indicates that the user's period is over.

Figure 4. The user's sensor registers a relative drop in BBT. The smart mirror calculates that the user is ovulating, shining a pink light to indicate that.

Introduction

Every menstruating person's period is completely unique. One's menstrual cycle can be affected by stress, illness, medicine, pregnancy, etc. Period tracker apps on the market today attempt to estimate periods based on a standardized 28 day long cycle, but they require users to manually record data and rarely account for the aforementioned factors. Is there a better, more convenient way to get an accurate picture of menstruation? We address this question by using a sensor to track BBT over time. BBT provides more accurate and personalized data, as it rises and falls throughout an individual's menstrual cycle. During the menstrual cycle, two hormones circulate the body: estrogen and progesterone. Estrogen stimulates the release of an egg from the ovaries and is active during the menstruation and follicular phase of the cycle. During the luteal phase, which lasts from ovulation to menstruation, progesterone production increases. This increase in progesterone causes a small, but easily measurable increase in BBT [9]. We offer a wireless wearable armband with an integrated temperature sensor that automatically collects user's data. A separate smart mirror then displays the collected information. Depending on where the user is in their menstrual cycle, the mirror will output a different color. By using a wearable and smart mirror, objects users are already familiar with, users can easily integrate their menstrual data into day to day life in a non-intrusive manner. This is significant as one's menstrual cycle impacts every aspect of their daily lives (weight, acne, moods, energy level, etc.). Many people who experience periods have to rearrange their lives around their menstrual cycles. Yet, due to both a lack of thorough sexual education in schools and understanding of menstruation, people are often unable to holistically understand their bodies. As Kannabiran et al. states, work involving sexual health is "much

needed and can have immediate and positive effects on human life" [7]. Our goal is to create a tangible user interface aimed towards individuals who experience menstruation, so that they better understand their own bodies and may optimize their day to day life. On a larger scale, we hope Crimson Wave will stimulate discussion about the stigma surrounding menstruating bodies.

Related Work

Mobile application stores are inundated with various period, fertility, and birth control tracker apps that help users track a niche aspect of their menstrual health. In general, these apps are not based upon the user's day-to-day physical changes. Instead, these apps simplify the concept of a menstrual cycle, espousing the idea that there is a "perfect", regular period that is 28 days long on average. These apps also happen to be overwhelmingly coded with traditionally feminine characteristics. For example, the user interfaces are adorned with flowers and text that assume the user's gender by making "she/her/hers" the default pronouns. In our project, we seek to include everyone who experiences menstrual cycles, regardless of gender identity. Another characteristic of these types of mobile apps is that they send a great deal of push notifications to the user to remind them to record their daily, menstrual happenings. The sheer number and frequency of these notifications can annoy users, particularly when they are busy.

While researching menstrual health we found a limited number of relevant papers. As discussed in *Hacking Women's Health*, women's health appears to be treated as a taboo topic in research [11]. Here, we recognize that many health issues associated with women's health, notably menstruation, affect more than those who identify as women, such as those who are transgender or intersex. Devices and technologies that

Figure 5. The user is wearing the soft armband that takes the user's basal body temperature.

are related to women's health appear to distance themselves from the "'dirty work' of women's health" [13]. 'Dirty work' is defined as intimate care, usually associated with "personal hygiene, bodily functions and bodily products, which demand direct or indirect contact with or exposure of the sexual parts of the body as defined culturally by the individual" [13]. Instead of this more intimate care, more peripheral assistance is provided, such as advice about maintaining health throughout pregnancy and improving how health records are shared [13]. Avoidance of the body, as if it were taboo, has implications for the future of HCI [13]. A few papers deal with the role technology can play in helping a person track their menopause [10] [14]. One is an analysis of users' needs in designing the user interface of mHealth [10]. Another paper discusses functional aspects and interactions that should be integrated in mobile apps to empower people in monitoring their menopause [14]. Others consider personal informatics with respect to menstrual health, indicating that while mobile apps can be convenient as a means of logging information, they are largely unhelpful in predicting periods as well as taking into consideration biological milestones in the life of a person who is designated female at birth (DFAB) [2]. These papers are relevant because they show a need for more research and development of technology directed towards the different stages of menstruation. Additionally, they show the flaws in conventional methods of predicting periods based on formulas. Currently, there is a product on the market called Lady-Comp that might appear to accomplish the same goal as Crimson Wave [9]. However, there are key differences between the two systems. While both Crimson Wave and Lady-Comp rely on BBT to help users gain an understanding of their unique menstruation cycles, Crimson Wave makes the temperature recording process faster and easier. Lady-

Comp requires the user to take their temperature using a thermometer and input their menstruation days manually, while Crimson Wave's wearable will record the user's BBT at the appropriate time without the user having to put in effort to do so. The goal of Lady-Comp is to help the user predict their fertile window, while Crimson Wave strives to give users a more holistic picture of their full menstrual cycle. For that reason, the outputs of Lady-Comp and Crimson Wave are very different. Finally, Lady-Comp is coded for ciswomen, and the product is very exclusionary. Crimson Wave is more inclusive of all people who may experience menstruation and fertility.

Regarding smart mirrors, Impressions Vanity Company designs their mirrors with features such as Bluetooth audio, dimmable lights, and hands-free phone call capability [5]. While these are certainly attractive features, the Crimson Wave mirror is designed with the AmbientROOM philosophy in mind, so a periphery experience is the goal [6]. Crimson Wave's mirror functions as both a mirror and physical representation of one's menstrual cycle. It would, in fact, detract from the purpose of Crimson Wave if more functions were added; unlike the smart mirrors from Impressions Vanity Company, our mirror is intended to naturally integrate into the user's environment.

Design

Crimson Wave is designed as a circular mirror that is surrounded by LED lights (Fig. 6). The LEDs use different shades to indicate where the user is in their menstrual cycle based on the red color intensity. For example, if the LEDs are a deep red, the user is menstruating (Fig. 2). Additionally, Crimson Wave is comprised of a wearable armband that is worn at night (Fig. 5). This armband is made of a soft material and has a biosensor that tracks the user's BBT. BBT is impacted by physical activity as movement causes a
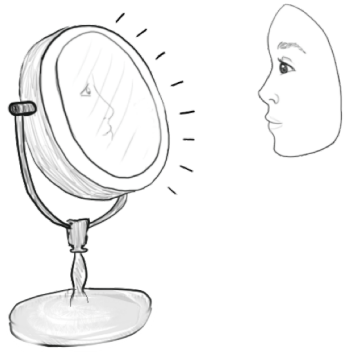
Figure 6. The Crimson Wave user interface is inspired by the AmbientROOM and based upon Fishkin's "embodied" and "metaphor" taxonomy. The relationship between the Crimson Wave's input and output is "environmental" and the metaphor is founded on the verb "to reflect" and the common action of looking into a mirror.

rise in the body's core temperature. Thus, measuring BBT automatically at night, when the user is least active, allows the sensor to collect the most accurate resting core temperature. BBT is a non-invasive way of monitoring a person's menstrual cycle, and it can be mapped to a time series that helps predict what is going on in the menstrual cycle [8] [4]. BBT drops during ovulation, rises during periods, and hangs around the user's baseline BBT for the rest of the cycle [8]. The user's data is sent wirelessly to a computer that tracks and stores BBT readings to develop a personal and clear analysis of their menstrual cycle. The wearable is portable and can be worn constantly if the user prefers not to take it off. We believe that this project is especially useful because it gathers data in a way that does not interrupt the user's routine. For example, by displaying visual updates of the user's menstrual cycle on the smart mirror, the TUI is effectively integrated into the user's movements in a room without turning its use into a task or something the user must worry about. It also engages a certain level of privacy by presenting information in the user's personal space using colors rather than disruptive audio or notifications.

Concept

The concept of the AmbientROOM from Hiroshi Ishii and Brygg Ullmer's *Tangible Bits: Towards Seamless Interfaces Between People, Bits and Atoms* strongly impacted the design of the Crimson Wave tangible user interface [6]. Crimson Wave is designed to activate the user's private space, whether that be their bedroom, bathroom, or vanity. The user will not have to consciously keep track of their menstrual cycle, instead the Crimson Wave wearable and smart mirror provides peripheral information. The user will position Crimson Wave where they would put a normal mirror; in this way, Crimson Wave is embedded within the user's

environment and does not occupy their attention in the same way a mobile app would.

Based off of AmbientROOM, the framework that structures the Crimson Wave interface is the taxonomy proposed by Kenneth P. Fishkin in *A Taxonomy for and Analysis of Tangible Interfaces*, which uses "embodiment" and "metaphor" as its two axes [3].The wearable relays data to the smart mirror within the same room; however, the input from the wearable and the output of colored light emitted from the mirror are viewed as two separate entities. Crimson Wave relies on a metaphor based on the verb "to reflect." When a person looks into a mirror, they see information about themselves. The Crimson Wave interface expands this idea so that when a user looks into the mirror, they see information about their menstrual cycle "reflected" there.

Implementation

The wearable is designed to be a flexible and comfortable band worn on the upper arm, allowing the temperature sensor to touch the user's skin and collect data while the user sleeps. The upper arm provides a more accurate reading of BBT because it is closer to the body's core. The armband is comprised of a LightBlue Bean+, which comes with a rechargeable battery and integrated temperature sensor. The LightBlue Bean+ was chosen for its built-in sensor and the ability to easily transfer wireless data to a computer. Upon reading the data, our computer program isolates the user's BBT based on the time of the data collection and the average temperature.

The mirror has a complete circle of 60 ultra bright smart LED NeoPixels surrounding it [12]. A 3D printed outer ring is set on top to create a glowing effect from the lights. The NeoPixels are connected to an Arduino Uno [1] that is connected to the computer receiving the data input. Based on the temperature that is recorded

in the log, the NeoPixels RGB values change. As the temperature decreases, the lights become redder, indicating an approaching period. The user will transition through various menstrual stages: follicular phase, ovulation, and the luteal phase. Their BBT will climax during ovulation and, as their temperature shifts, the lights will change in saturation from white to pink.

Conclusion and Future Work

Crimson Wave is a mirror with a light display that informs users where they are in their menstrual cycles based on a temperature sensor in the connected wearable. Crimson Wave will show users a holistic view of their menstrual cycles, beyond just their period and ovulation. This project highlights the need for more products that focus on menstrual health and teaching the public about the different stages of menstruation. Interaction with the product is effortless and easily integrated into normal daily activities. We plan to evaluate the wearable's accuracy in measuring BBT, improve our formula for collecting data, strengthen the way our tangible user interface interacts with the database where user information is stored, and expand the information presented by the mirror. The Crimson Wave prototype was presented in a classroom setting and received a positive response. Suggestions included: allowing collected data to be easily presented to health professionals, presenting calendars and graphs with the user's data, and adding touch screen capabilities. In the future we will evaluate Crimson Wave in home settings. We intend to explore how perceptions of the mirror might change depending on the number of people in the environment, specifically people who live alone versus people who share their space with a partner or roommate.

Ultimately, menstrual cycles are a given in users' lives. While it impacts their day to day health, it does not dominate their routine. Therefore, the technology that optimizes their menstrual health should represent this. Crimson Wave seamlessly and subconsciously integrates insight into users' bodies using familiar objects.

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