# Reading Face, Reading Health: Exploring Face Reading Technologies for Everyday Health

**Xianghua Ding**
Shanghai Key Laboratory of Data Science, School of Computer Science
Fudan University
Shanghai, China
dingx@fudan.edu.cn

**Yanqi Jiang**
**Xiankang Qin**
School of Computer Science
Fudan University
Shanghai, China
16307130316@fudan.edu.cn
17210240182@fudan.edu.cn

**Yunan Chen**
University of California Irvine
Irvine, California
yunanc@ics.uci.edu

**Wenqiang Zhang**
School of Computer Science
Fudan University
Shanghai, China
wqzhang@fudan.edu.cn

**Lizhe Qi**
Academy for Engineering & Technology
Fudan University
Shanghai, China
qilizhe@fudan.edu.cn

## ABSTRACT

With the recent advancement in computer vision, Artificial Intelligence (AI), and mobile technologies, it has become technically feasible for computerized Face Reading Technologies (FRTs) to learn about one's health in everyday settings. However, how to design FRT-based applications for everyday health practices remains unexplored. This paper presents a design study with a technology probe called Faced, a mobile health checkup application based on the facial diagnosis method from Traditional Chinese Medicine (TCM). A field trial of Faced with 10 participants suggests potential usage modes and highlights a number of critical design issues in the use of FRTs for everyday health, including adaptability, practicality, sensitivity, and trustworthiness. We end by discussing design implications to address the unique challenges of fully integrating FRTs into everyday health practices.

## CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**.

## KEYWORDS

Face Reading Technologies, health, wellbeing, Traditional Chinese Medicine, TCM, face diagnosis, design study, self care


*CHI 2019, May 4–9, 2019, Glasgow, Scotland UK*

ACM ISBN 978-1-4503-5970-2/19/05…$15.00
https://doi.org/10.1145/3290605.3300435

**ACM Reference Format:**
Xianghua Ding, Yanqi Jiang, Xiankang Qin, Yunan Chen, Wenqiang Zhang, and Lizhe Qi. 2019. Reading Face, Reading Health: Exploring Face Reading Technologies for Everyday Health. In *CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2019), May 4–9, 2019, Glasgow, Scotland UK*. ACM, New York, NY, USA, 13 pages. https://doi.org/10.1145/3290605.3300435

## 1 INTRODUCTION

The human face has long played a major role in the identification of people, emotional communication and others. With the recent progress made in artificial intelligence, computer vision and mobile technologies, we have witnessed an increasingly wide application of computerized Face Reading Technologies (FRTs) in our daily lives. For instance, face recognition technology, which recognize the identity of a human face by comparing it with known images in a computer space [50, 60], has been widely applied in all domains for attendance management, access control, and security (e.g. Apple Face ID). Besides, the use of FRTs has also been explored for emotion recognition [9], fortune telling [34, 54], and even IQ detection [32]. With FRTs becoming increasingly accessible and more advanced, there are opportunities to apply them to increasingly broader areas of everyday life.

This paper explores the use of FRTs for everyday health practices. The face is believed to reveal signs of various health conditions or even diseases of the internal body. In the medical domain, direct observation of the face is part of the medical diagnosis when a doctor assesses a patient's overall constitution and derives an initial hypothesis of a possible disease [7]. For instance, people with hepatitis and other liver issues may have a face or eyes with a yellow tone [35]. The face can also indicate one's overall mental and emotional wellbeing, revealing states of tiredness or fatigue. Overall, a lot about one's health can be learned simply by observing one's face.

In particular, facial observation has been an important component of the diagnostic methods used in Traditional Chinese Medicine (TCM), which includes observing (face,

tongue and others), listening and smelling, pulse feeling and asking questions. Based on these techniques, a variety of computer assisted tools have been developed for clinical purposes, including facial diagnosis [36], tongue diagnosis [58], and pulse diagnosis [52]. Only recently, however, have the advancement and increased portability of technologies turned some of these tools into devices for everyday patient use. For instance, a range of wearable and portable pulse reading devices, such as the fingertip pulse oximeter[1], have become commercially available for everyday health monitoring.

The recent advancement of FRTs has also made it technically feasible to bring computerized facial diagnostic techniques into everyday life. However, it is still largely underexplored in terms of how systems can be designed to integrate FRTs into everyday health practices. More specifically, a number of research questions remain open for investigation. Who will use FRTs for health purposes in everyday life? What health conditions may FRTs be used for? What information do people expect to receive from FRTs? What unique challenges might there be when designing FRT applications for everyday health use?

To answer these questions, we conducted a study with a technology probe called *Faced*, an FRT-based mobile health checkup application developed through a collaboration with TCM doctors. One can use *Faced* to take photos of his/her face and tongue, and after answering a few questions, the application will show health evaluation results based on TCM, indicating how balanced or imbalanced the user is in terms of constitutional type, and provide corresponding advice to help restore balance through everyday actions, in terms of diet, massage and exercise. As such, *Faced* is designed as a consumer health application for everyday health maintenance and not for disease diagnosis or medical treatment. A field trial of *Faced* with 10 participants revealed the potential for the use of FRTs for everyday health, and at the same time also highlighted a number of design issues to be addressed in related applications that are to be fully integrated into everyday health practices.

In the sections below, we will first provide a general background of TCM diagnostic methods and facial diagnosis in particular, and then review related work on FRTs and everyday health in HCI. We will then present our study and our findings. We will end by discussing the design implications for FRT-based applications for everyday use.

## 2 BACKGROUND OF FACIAL DIAGNOSIS IN TCM

The TCM diagnostic method includes four parts: observing the facial features, listening and smelling, asking about the symptoms and measuring the pulse [5]. More specifically, when a patient comes to a TCM doctor for help, the condition of his/her face and tongue is examined first. Then the doctor will listen to the patient's voice and smell to detect any body odors. Next, the doctor will ask questions to learn more about the patient's symptoms and the related details of his/her daily life. Finally, the doctor will take the patient's pulse, usually on his/her wrist. Then, a diagnosis can be made.

Facial examination, including the inspection of the face and the tongue, has always been a primary component of the diagnostic method in TCM. In facial examination, facial color is important. TCM divides facial colors into five categories: green, yellow, red, white and black. A change in facial color or luster is believed to reflect pathological changes in the human body. The tongue examination is to detect any disharmony in the state of the organs by looking at the shape, size and color of the tongue body and coat [20, 22]. The results of these two examinations, after careful analysis and synthesis, can be used to indicate the general health of a person and detect underlying problems.

## 3 RELATED WORK

### FRTs in Everyday Use

Due to the rich biometric characteristics of the face, FRTs have been widely applied in many different domains. FRTs are now commonly used for security and access control [44]. FRTs have also been used for emotion detection and have been explored for related everyday practices. For instance, a smile-activated refrigerator detected facial expression, automatically unlocking the refrigerator if a smile was detected, with the hope of encouraging users to smile more [56]. In addition, FRTs have been applied to cosmetics. For example, in order to boost shopping, famous cosmetics retailer Sephora developed a digital makeup system that shows the products on a facial photo of the consumer [30].

In the medical domain, FRTs have mainly been explored for the use by medical professionals. For instance, FRTs are used to identify patients when medical emergencies occur so as to provide reliable and timely access to the patient's medical information [40]. Cloud-assisted speech and face recognition has been explored to remotely monitor patients' health while they are at home [25]. FRTs for TCM-based diagnosis has also been developed for clinical use [64].

However, work on FRTs for everyday health by non-health professionals is still limited. Closest to our work is a mirror system developed to use FRTs and other sensors to monitor patients well-being with respect to cardio-metabolic risk [2]. A follow up questionnaire-based usability study at three centers suggests a good, overall acceptability of the system [8]. However, with the appearance of a conventional mirror,

[1] http://www.jinmuhealth.com

this system is meant to be installed and can only be used in an indoor setting.

### Everyday Health Technologies

Different from the traditional clinical approach, recent HCI studies have begun to explore the role of technology in facilitating and enabling healthcare in everyday life. A broad set of studies have looked into some of the everyday healthcare activities patients and caregivers engage in for chronic illness management, including diabetes [21], dementia [59], multiple sclerosis [3], bipolar disorder [18], and even a combination of multiple chronic conditions [17].

The technology prototype based user-centered design approach is often employed to inform the design of health technologies for everyday use. For example, Papi et al. used a focus group approach for a wearable knee monitoring prototype, and identified design requirements and usage modes for rehabilitation tools for patients with osteoarthritis (e.g. not looking like a medical device is important for patient adoption) [46]. Similarly, Singh et al. conducted a 1-2 week home study to investigate how people with chronic pain use a wearable sensing technology to do everyday functional activities [53]. Although the technologies investigated in these two examples are not FRTs per se, they are similarly concerned with health technologies in everyday use and employ prototype based user-centered design approaches to develop a deeper understanding of potential use and further design opportunities.

As a recent review points out, technologies for everyday health are often designed to foster reflections, suggest care activities, share information and enhance collaboration with caregivers [17]. Studies show that technologies help people with chronic diseases understand the course of their disease, react to fluctuations in certain measurements, assess health behavior and adjust to relevant conditions in daily life [3]. Take diabetes as an example, researchers have put forward solutions [21, 43] to facilitate patients' understanding of the associations between glucose levels and daily activity. Taken together, these studies show that health management is deeply embedded in people's daily lives and shaped by a variety of mundane activities such as diet and exercises [39].

Beyond illness management, technologies for more general health have also been studied in HCI. In particular, many studies have examined how technology can be designed to better support healthier lifestyles, such as better eating habits [29], exercise [47], and good sleep [31]. In particular, health tracking and monitoring systems have been created to allow people to monitor and get feedback on their health. Broadly speaking, the variables that can be monitored on these technologies are of two categories: daily behaviors such as food intake, exercise, and sleep habits [15, 16, 19, 38] , and specific health indicators such as blood pressure [13, 14, 24].

These health tracking and monitoring technologies, though promising tools in people's daily lives, are primarily based on quantified measurements [37]. How to design technologies to facilitate the use of other types of health indicators, such as facial observation, into peoples daily lives, has remain unstudied in HCI. It is unclear how people will respond to such technology, and how it should be designed.

## 4 THE STUDY

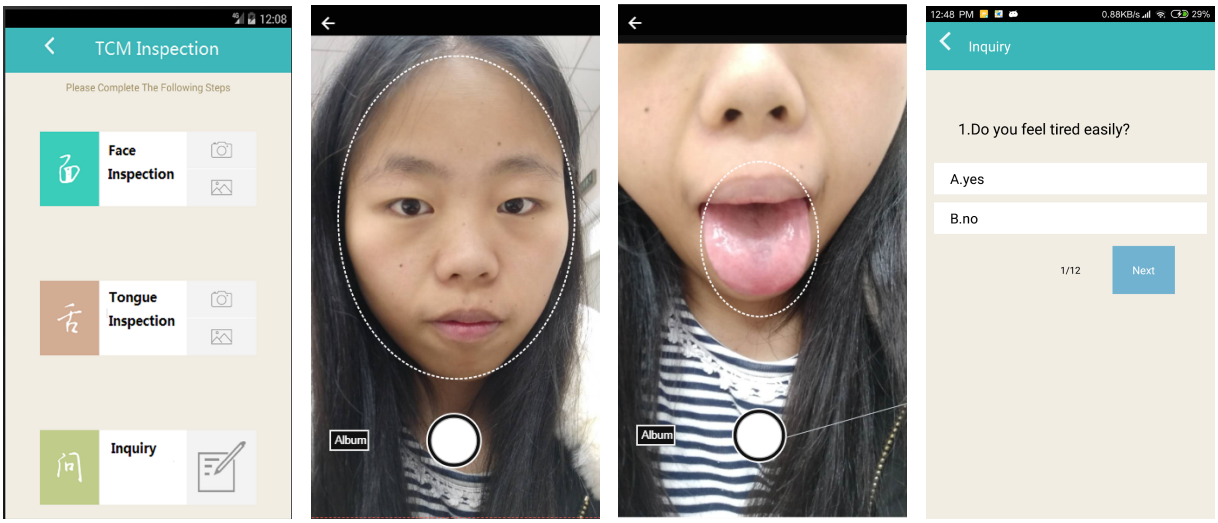
Our study was an exploratory one using a technology probe called *Faced*. A technology probe [27] is similar to a cultural probe [23] in that both are co-design techniques that use a set of artifacts as a probe to encourage the active participation of users in technological design, especially in complex personal and private environments. However, unlike cultural probes which use various cultural artifacts to inspire people to reflect on their lives so as to generate design inspirations, technology probes directly expose users to simple, flexible, and adaptable technology so as to understand their needs and desires in a real-world setting, field-test the technology, and inspire both users and researchers to think about new designs and technologies.

### The Technology Probe – Faced

For our technology probe *Faced*, we adopted and appropriated a FRT for health checkup [64], incorporating TCM-based face and tongue inspection techniques. The technology was originally developed and deployed for TCM clinical diagnosis and not for everyday health purposes. However,*Faced*, as a mobile version of it (android platform only at the time of study), had recently been developed, and this as such made it more easily available for everyday use.

*Faced*'s underlying face and tongue inspection model was developed in cooperation between us and TCM doctors from Shanghai University of Traditional Chinese Medicine. In the model, a facial photo is first pre-processed with color correction and image quality optimization, and then a facial or lip segmentation [26, 65] is employed to cut out images of the face or lips, dependent on which deep learning and SVM are being used for the feature extraction. Features selections and related rules are based on TCM theory [61, 63], and come from instructions provided by the TCM doctors. Features include face color, face gloss, lip color, tongue color, tongue fur color, and tongue shape. A more detailed feature description and evaluation can be found in [64]. The model qualitatively classifies health statuses into a number of TCM-based categories.

To ensure the accuracy and effectiveness of the model, the TCM doctors were involved in the whole development




(a) main interface (b) face interface (c) tongue interface (d) inquiry interface

(e) results

**Figure 1: Faced Interfaces**

process. The facial pictures used for the feature classification training of the model were collected from 150, 000 volunteers from 10 local hospitals and 10 communities, all selected by the TCM doctors to ensure gender balance and age coverage. Picture data were collected in both the standard (using a TCM integrated diagnosis instrument with standard camera, light, and user posture) and the open (cell phone, indoor and outdoor) environments. All data were annotated by the TCM doctors, with each sample annotated 3 times by different doctors for cross validation. Samples with inconsistent annotations were removed from the data set. The diagnosis model was also evaluated using 2,000 volunteers, with an accuracy of 85% compared to the results of the TCM doctors. Health advice was provided by the TCM doctors based on different constitutional types detected by the diagnosis model.

To use *Faced* for everyday health purposes, users can install the application on their smart phone, and use it whenever and wherever they want. After they complete the three steps - face photo collection, tongue photo collection, and the completion of a few questions, they will receive a health report, including facial and tongue descriptions, a health score, a description of their health status, and corresponding advice for health improvement. In other words, *Faced* is already feasible for everyday use for health management.

Figure 1 illustrates the interfaces of *Faced*. The main interface shows the three components of the diagnosis: face, tongue, and inquiry. For the face or tongue interfaces, users can either choose from the photos stored in the smart phone,

or take a new one with the smart phone camera. When users finish the photo taking, *Faced* will return to the main interface, which will either show a description of the face or tongue using TCM terms in the corresponding interface area, or provide a message saying that the photo is not qualified. For a qualified photo, the lighting should not be too bright or too dim and users must directly face the camera. In addition, the photos should be of the proper size, as is specified by the dashed box. After the photo collection process, users can enter into the inquiry interface. Guided by The Eight Principal Syndromes and the Constitutional Theory in TCM [48, 62], 12 multiple choice questions are provided for users to answer, covering the topics of fevers and chills, sweating, head-body and chest-belly symptoms, taste and diet, stool and urine, sleep, and mood.

After the users have answered all the questions, the data are then automatically analyzed and a health report is given to the users on the results interface, as shown in Figure 1. The corresponding health report will also be automatically saved locally to the users' smart phone. If the users do not finish all the steps or give up in the middle, no records will be saved. No information about the underlying analysis model is shown on the interface.

We consider *Faced* an ideal technology probe to investigate FRTs for everyday health. First, it incorporates all necessary techniques from image processing, machine learning and TCM to provide users with a functioning system to try out. Second, although originally developed to be used during medical visits, *Faced*, as a mobile application, can now be easily installed onto smart phones, and the interface is simple enough for everyday use. Third, the technology probe approach is also a recognized way to explore design opportunities for domestic and everyday lives [4, 28, 33, 41, 45]. As such, we employed *Faced* as a technology probe in our study.

### Methods

We conducted a field trial with *Faced* as a technology probe to better understand how to design FRT based applications for everyday health. For participant recruitment, we used the snowball sampling approach, starting with people in our own social network, using a recruitment poster designed for the study. As the application only ran on the android platform at that point, we only recruited those who used android smart phones. We tried to balance participants from different backgrounds, with varying ages, health conditions, educational levels and work environments, as these factors account for different life experiences, attentions paid to personal health, and acceptance of new health technology. Eventually, 10 participants in total were recruited for our study. The profile information of our participants is shown in table 1.

We met with our participants and conducted face-to-face interviews with them twice: an introductory visit before *Faced*'s deployment and a concluding visit three weeks after. Each introductory visit involved introducing *Faced*, offering technical help for the installation, and interviewing the participant about his/her age, work environment, current health condition, use of existing health technologies, and knowledge of TCM. During the installation and first trial of *Faced*, we observed participants' behaviors and paid attention to their uses of the application and their reactions to the results. The instructions were to use *Faced* at their discretion during the next three weeks. That is, no compulsory use was required and users were free to use the application at any time. During the trial period, we maintained contact with participants and encouraged them to interact with us whenever they came across any problems or wanted to share their use, e.g. their mood, health condition, etc.

We scheduled semi-structured interviews with participants after the field trial. We used the health reports recorded on their phones and the feedback we received during the trial period as cues to ask specific questions about their use practices. More specifically, we checked the report records to examine usage cases, as well as the specific usage context, e.g. what time and where the application was used, and whether there were others around. In addition, we also inquired into the users' own perceptions and interpretations of the results. Finally, we encouraged participants to talk about how they would like to use this kind of application for their everyday health and what features they would like to have.

We audio-recorded the interviews with the participants' permissions and transcribed them for data analysis. As we had promised to present participants' information in an anonymous manner and not make their health information public, the participants did not need to worry about their privacy and were willing to have their voices recorded. The authors then coded the transcript data independently. Through discussions, we identified themes emerged in the data, and returned to the transcripts to find more data for these themes. After several loops of analysis, we arrived at the findings as well as the design implications as presented in the next section.

## 5 FINDINGS

From the automatically saved health reports, we found that the majority of participants used *Faced* about four times over the study period. However, the use was mainly concentrated during the first few days. With the exceptions of P2、P3、P8 and P10, the participants had stopped using the application and some had even uninstalled it by the end of the study. Our interviews revealed various reasons participants stopped using *Faced*, including insufficient technical literacy, usability issues, not expecting to see any health

**Table 1: Participants**

| ID | Gender | Age | Education/Occupation |
|---|---|---|---|
| P1 | M | 20s | Computer Science/Ph.D Candidate |
| P2 | M | 20s | Computer Science/Graduate Student |
| P3 | M | 20s | Computer Science/Graduate Student |
| P4 | F | 50s | Hospital Care Worker |
| P5 | M | 40s | Office Worker |
| P6 | F | 40s | Kindergarten Teacher |
| P7 | F | 50s | Office Worker |
| P8 | F | 10s(19) | Computer Science/Undergraduate Student |
| P9 | M | 20s | Computer Science/Office Worker |
| P10 | F | 40s | Office Worker |

changes in a short period of time, and having a busy schedule. In this section, we will present the potential usage of Faced for everyday health, as well as some design issues uncovered in the study.

### Potential Use

As expected, those who had more health concerns or were already actively engaged in health activities were more interested in *Faced* and saw more clearly how it could be integrated into their daily lives. P1 was such an example. He had been weak and illness-prone in his childhood, and had used TCM for treatment and prevention since then. He commented: "*For people like me who is always ill, whose health condition is not so good, it may be used everyday, as I want to prevent diseases from happening.*" P3 particularly liked that it took his personal health conditions into account when providing health advice: "*Because it could do face and tongue inspections, and based on the results, it tells you, for the instance of foot massage, where the acupoints are, and I feel it is quite useful.*" P10 was probably the most enthusiastic: "*The diagnosis result made sense to me, and the suggestions were useful... Because it was so convenient to use it on the smart phone, I used it whenever I had time... I had some time today, so I opened the application and used it.*"

More specifically, our participants appreciated that the application could help them understand their own health statuses, so they could adjust their lifestyles accordingly. For instance, P3 described a case where he used *Faced* when he felt very tired one morning and not surprisingly received a score of 65 – the lowest since he had started to use *Faced*. He described how *Faced* could be useful for him to make health related decisions: "*As a student, I may remain sedentary for a long time. When I feel tired or uncomfortable, I could open Faced to get suggestions, then decide if I need exercises.*" P1 also commented that *Faced* could assist him in making everyday health decisions: "*[With Faced], I could know my overall health condition every day. Then I can determine whether to work for extra hours or not [based on the results].*"

Additionally, participants envisioned *Faced* as a leverage to facilitate communication between healthcare providers and patients, as similarly found for other health tracking technologies [17, 46]. For example, P8 proposed that *Faced* be incorporated into medical management systems: "*A doctor can check the health conditions of his patients through this application and get informed on a timely manner if something goes wrong.*" She further suggested: "*The health reports can be saved in a personal dossier, and then the doctor can have easier access to a patient's medical information.*" Used in this way, the application could be a tool to provide supplementary information for doctors to understand the patient's everyday health situations during medical visits.

As these cases show, our participants embraced the idea of applying *Faced* to their everyday health and even envisioned complementary ways to use it. At the same time, our analysis also revealed major design issues for the full integration of *Faced* into their daily lives, as elaborated on below.

### Adaptability

From the study, we found that one primary factor preventing participants from using *Faced* more was that the application always asked the same questions and frequently showed the same results. P1 pointed out: "*No matter when I took a picture, it always asked the same questions. If I were asked to use it on an everyday scale, I would feel quite bored.*" P2 similarly commented: "*It's just boring to check the same thing.*" P6 explained why she had stopped using *Faced*: "*One's health condition does not change a lot in a short period of time.*" P7 wanted to continue to use *Faced*, but was discouraged by seeing the same information all the time: "*This application gave me the same answer (result) every time.*" As such, our

data suggested that getting the same questions and the same results every time could be the main reason why so many stopped using it.

Our participants also suggested that the system could be more adaptive such that they did not need to redo or resee the same things every time. Specifically, making the system more adaptive based on users' personal or contextual data was suggested by our participants.

*Adaptive to Personal Data.* In our study, we found people expected the system to be able to remember their personal conditions and adapt accordingly. For example, some participants complained that answering the general personal health questionnaire every single time was very burdensome; rather, they expected the system to adapt the questions based on an analysis of the prior input. For instance, P2 commented: "*The inquiry part is not well designed. The questions are fixed and too generalized.*" He suggested that the questions be more personalized: "*I think the questions should be more specific and be tailored based on the results of face reading as well as the answers to the precedent questions.*"

More so, when people were expecting changes in their personal health conditions, e.g. when they were actively managing their health, or experiencing new health issues, they hoped the system could highlight the changes. For instance, P10 said: "*I hope it has a followed-up tracking process. It not only assesses your health condition today and gives you some suggestions, but also tracks that problem in the following days and adjusts its suggestions accordingly.*" P3 had similar design suggestions: "*The current system only has diagnostic functions. It does not have followed-up functions. After giving the initial health advice, it should track the state of the user to see whether the suggestions work for him, and make some adjustment accordingly.*" Thus, providing tracking capabilities in terms of remembered historical data, and highlighting changes over time would be very valuable for it to be incorporated into an active health management loop.

*Adaptive to Contextual Factors.* During our study, some participants, especially the older ones, also suggested that the health advice take environmental factors such as seasonal changes into account (According to TCM, harmony with natural change is important for health maintenance). For example, P6 suggested: "*The application should provide us with more guidance for health maintenance. It'd better provide rich information with more variations, e.g. by taking seasonal and solar changes into account.*" P10 further suggested that the health information and seasonal information be combined for consideration when advice is provided: "*What should people with certain constitutional characteristics do to keep healthy on dog days*[2]*?* " As these quotes show, even when participants' health condition stay the same, we can still make the health information more varied, by adapting it to environmental changes.

**Practicality**

In addition, we found that not all the participants understood their results on the health reports, and many felt that the standardized advice was not practical enough for their own situation.

*Literacy Gap.* As mentioned in a earlier section, *Faced* was designed in collaboration with TCM professionals and presents a health report based on standardized TCM descriptions. However, several participants told us that it was very hard for them to understand some of the TCM terms used in their reports. Especially, we found that student participants were not familiar with basic notions of TCM, probably because TCM is not widely used among young people today. For example, P2 revealed that he did not understand Qi (the vital life energy): "*I don't know much about TCM. For example, it says I am Qi-Deficient. But what is Qi?*" P8 also admitted that she had limited knowledge of TCM, and gave an example to illustrate that: "*Below (the score), it talks about the five organs. Actually I don't quite know. Right. I don't even know what the five organs are. They likely include heart and kidney, and liver...en, I can't quite name all the five organs...*" These quotes show that although TCM has existed in China for thousands of years, people today do not always know the basic concepts. Differing health literacy levels should be taken into account then when the system is designed in order to be used by lay people in their daily lives, as similarly pointed out in [42].

Some participants themselves suggested ways to address this literacy issue. One way would be to associate TCM related terms with everyday health terms that lay people are more familiar with. For example, some participants preferred to see the terms they knew more about such as cold and headache, instead of the TCM terms. P1 provided such a case: "*I caught cold today, but Faced didn't show me any sign of cold. Instead, it tells me that I am Qi-deficient and blood-deficient. Why not directly tell me about the cold?*"

It was also suggested that the health guidance be explained in a more direct and vivid way, such as using videos, as participants found it difficult to follow the steps provided through words and pictures. P1 suggested using videos to show how to massage, so that it would be easier to put into practice: "*When I'm trying to press on the acupoints through*

[2]The three 10-day periods between mid-July to mid-August that are predicted to be the hottest days of the year, and there are some traditional ways of spending these days of summer.

*massage, I'm unwilling to read the picture. If there's a video teaching me what to do, it will be much better."*

Providing mechanisms for people to learn about health related knowledge is a way to address this literacy gap. As a matter of fact, some informants saw *Faced* as providing a personalized way of gaining health knowledge. For example, P10 expressed an interest in learning more about health: "*I think it can provide us with a wider range of health related knowledge. After all, we are not professionals who know a lot about which kind of food is good for health and which is not."* She told a story of how she, after *Faced* suggested her massage particular acupoints, compared meridian diagrams at home and information on *Faced* to learn about acupoints. That is to say, while it is common for the media to spread TCM related knowledge, participants took this application as an opportunity to access it in a more personal and thus more effective way. Some participants even suggested that sharing and discuss health results with others as a way to enhance this learning. In summary, when learning is concerned, rich media, a more personalized approach, and sharing and socialization are all possible means of support.

*Advice Practicality.* While the probe provided advice on how to improve one's health based on the assessment results, some participants found that some of the advice was not practical enough to apply to their own situation. For example, P2 pointed out that as a student living in a shared dormitory with no kitchen facilities, some of food therapies were impractical for him: "*As a student, I am unable to cook. It is just impractical.*" For P8, some suggestions were not economically feasible: "*The materials needed in the food therapy are too expensive. It goes beyond what I could afford."*

In addition, being busy was also one major obstacle to putting the health advice into practice, as many TCM based diet and medication suggestions require a long time to prepare. P9, a graduate who had just found a job as an engineer and did not return home until 8 p.m., reported: "*I have no time for simmering congee or decocting medicinal herbs."* For P7, doing something everyday seemed too much of a commitment: "*I cannot stick to everyday acupressure."* Taken together, these quotes indicate there were practical difficulties to following the health advice. This means, then, for the various suggestions given including food therapy, massage, exercises and others, it may also be good to be selective so that the suggestions better fit into each individual's situation.

### Sensitivity of FRTs for Everyday Health

Compared to other health technologies (e.g. measuring heartbeat, blood pressure, steps), we found the use of facial images makes the application more contextually sensitive, limiting where and how it can be used.

*Cultural Sensitivity.* In our study, we found that most of our participants only used *Faced* in private spaces, such as at home or in dormitories. This was especially true for the tongue photo taking used in our probe, as the act of sticking one's tongue out is laden with cultural meanings, e.g. signifying disgust or impoliteness, and as such can be considered inappropriate in many situations [51]. Participants reported that they felt embarrassed, or were afraid that they might unintentionally offend others when doing the tongue inspection with others around. In particular, the younger participants were more outspoken about this discomfort. P1, a graduate student, considered taking a picture of one's tongue inelegant and unacceptable: "*Sticking out your tongue is not elegant. Yon cannot do that in public places, can you? "* P3 described how he felt nervous about doing it in public: "*I feel nervous when taking a picture of my tongue with someone near me."* For this reason, participants would only use it in private. As P8 described: "*It is a terrible image [sticking out one's tongue in public]. I will use it only when I am in private spaces."* As such, the cultural norms around the specific action of sticking one's tongue out limited where this application could be used.

Meanwhile, interestingly, we noticed that those who were middle-aged or older participants, had less hesitations about it. For instance, P10, the only one who shared *Faced* with her neighbors and colleagues, considered doing a health diagnosis a justifiable reason: "*I do not feel very embarrassed. It is just a form of diagnosis.*" P4 suggested that age might make a difference: "*People of my age don't care about it.*" It was unclear why age mattered here, but probably because the accumulated life experiences made them more confident of what they were doing, or maybe health was more of a concern for them. Anyhow, it reminds us that cultural norms and personal life attitudes play a role here in the consideration of when and where it is appropriate to use FRTs.

*Technical Sensitivity.* In addition, the inspection model was based on a color analysis of the facial image, making it more sensitive to the impact of external factors, such as lighting and phone camera quality. As such, as reported by the participants, sometimes it was not easy to take a qualified picture. For example, P7 reported experiences of having to take the photo again and again until she eventually quit: "*It kept asking me to take another picture because my picture was not qualified. It is so cumbersome that I do not want to use it anymore."* In addition, people were afraid that features of the phone camera affected their diagnosis. For example, P2 was concerned with the impact of lighting as well as the camera on his result: "*Face inspection showed my lip was too pale, I think it's a result caused by the lighting or the beautification algorithms on my phone camera."* Similarly, P8 was not sure

whether the diagnosis was impacted by the touchup function that came with the phone camera: "*I am using a vivo smart phone now, and its camera is equipped with touchup function. If it uses this picture for diagnosis, it will not be so accurate, right?*" These concerns suggest that in order for FRTs to move out of a more controlled environment such as the clinical setting and into the everyday context, more varied environmental and personal equipment factors need to be taken into design considerations.

*Social Sensitivity.* While several participants wished to share their health results in an opportunity to learn from each other , at the same time, they also showed concern for the involvement of facial images and personal health information, e.g. the face could easily be used for personal identification. For example, P10 talked about how facial images were personal and as such inappropriate for sharing: "*I can share my symptoms and the relevant advice to some professionals in an anonymous manner. But something more personal, like facial images, is not on my sharing list.*" P8 reported that she did not even share selfies on her social network: "*I almost never post my selfies on social networks.*" Overall, although sharing facial images and health information with healthcare providers was considered acceptable, it was believed that special care should be taken for broader sharing when facial images were involved.

Interestingly, we found that, unlike other social sharing applications where people prefer to connect with those they know, participants in the study had more concerns about sharing with family members. As P3 mentioned: "*Sharing with strangers is a way to socialize. You can enhance your knowledge level [about TCM] as well.*" However, he explicitly mentioned that he would share the information with strangers, but not family members, as it might introduce unnecessary worry or control into their relationships, revealing a tension that existed between family members in terms of health information sharing, similar to what was reported in a prior study [49]. As such, the high sensitivity of facial images as well the personal nature of health information requires FRT based applications to be carefully designed to balance social functions and privacy concerns.

### Issues of Reliability, Trust and Sentiment

One of the goals of the study was to field test the underlying analysis model of *Faced* and people's attitudes towards such a new technology. During the study, we found that many participants were skeptical of the results generated from it. During the interviews, some questioned the reliability of the results, leading them to distrust the system. For example, when many participants saw bad scores, instead of reflecting on their health or lifestyle, they tended to distrust the system all together. For instance, P3 considered his bad score a result of system deficiencies: "*When I saw the bad result, my first reaction was that the application itself had deficiencies. I would not treat it as authoritative.*" .

As a matter of fact, without other mechanisms to assess the results' reliability, participants tended to use their own feelings. That is, if the result was consistent with what they felt about themselves, they would consider it reliable and continue using the application, otherwise they distrusted or even abandoned it. For example, P2 revealed: "*I was feeling well [today], but it gave me such a low score. I do not think my condition is that serious...And, it always gives me that low score, so I don't even want to use it anymore.*" On the other hand, when the participants had the results that were consistent with their feelings, they perceived the system as reliable. For instance, P5 said: "*I think it is actually well done. It corresponds well with my real situation. I think it makes sense.*" However, the personal feelings and perceptions stated by the participants in the interviews may not have reflected their real health statuses.

Additionally, our data also shows that the result could evoke emotional reactions, especially when the score was relatively low. For example, to P8, the lowering score was hard to accept, especially when it was not consistent with the lifestyle she was leading: "*It was a hard hit (seeing the score going from 89, 85, and then 70), because I was leading a very healthy life [in terms of sleeping and eating] then. I even got 89 when I led a very unhealthy life during the final. What is the hell!*". As already noted in previous study [55], health measurement could evoke negative emotional reactions, and special care should be taken to attend these negative results.

Some participants felt that they needed to better understand mechanisms behind the results so they can know how to assess the results. For example, P1 considered it was important to know where the results were from : "*It has to specify its source of information, otherwise I will not trust the results.*" p8, a graduate student majoring in computer science, wanted to evaluate the reliability of *Faced* based on what mechanisms were used to generate the result: "*Only a model based on deep learning can achieve the same result as an experienced TCM practitioner.*" Although Faced was actually based on collaborations with TCM professionals, and big data were used to train the model, since this information was kept invisible to users, and thus, had no impact on users' perception of the reliability and trustworthiness of the system. Probably one way to help users assess the reliability of the results would be to make the underlying mechanisms more visible.

## 6 DISCUSSIONS AND DESIGN IMPLICATIONS

In the preceding sections, we just presented findings from our study using *Faced* as a technology probe to explore FRTs

for everyday health. The study uncovered many design issues to be addressed. In addition, recognizing that the current system was still in an early stage of development, our participants suggested many design ideas. The majority of the design issues we found come from a change in setting from the clinic to patients' everyday lives, while the others are primarily related to the use of facial images.

### Sustainable Everyday Use of Health Technologies

Sustainable use is a common issue for everyday health technologies, particularly those that want to encourage behavioral changes. For example, while self-tracking technology has been commonly explored to encourage healthier lifestyles [37], studies have shown non-use or constant system abandonment [6, 11].

Our study also reveals common abandonment among our participants. Of course, frequency of use may not always be an appropriate measure for the usefulness of a technology. Unlike technologies for behavioral change where continual use is expected, health technologies like ours may only be used when needed. For example, as shown in our study, some said that they only used the system when they felt tired or during stressful times, such as finals week. At the same time, we also found that for those who were generally weak in health or were actively engaging in health activities, the application was more likely to be used continuously to help prevent illness, track changes and assess effects. However, as shown in the study, in its current form, Faced did not support continuous use very well. Our participants quickly lost interest in the application; among all the reasons for this, being asked to provide the same information repeatedly and not seeing much change were probably the most salient ones.

In the system, showing the same health information all the time had to do with the use of the TCM based qualitative approach for health assessment. As mentioned, our underlying facial and tongue diagnosis model is based on deep learning for feature classifications. Unlike quantitative measurements, such as blood pressure and steps tracking, for those leading a stable life, the qualitative category of one's constitutional type is likely to stay the same over a relatively long period of time, and so is the corresponding health advice. Thus, while the quantitative scores that were used in the assessment could fluctuate, most of the health information lacked variety, making it boring to some participants.

Based on our findings, we suggest an increase in the learnability and adaptability of the design as a way to better support continuous use when needed. For applications running on personal devices, such as Faced, we can leverage historical data to make it more adaptable and highlight changes over time, rather than asking or showing the same information all the time. That is, for those who experience some health changes (either by actively engaging in health related activities, or due to certain unhealthy behaviors they've adopted), the system would allow users to skip some or all the assessment questions if their answers remain the same, and highlight the new changes in their results based on the stored records. Meanwhile, doing so will also help collect longitudinal face reading data and offer opportunities to create more personalized results based on the historical data.

For people who are interested in learning about health and wellness, the system can be designed to provide context-aware health information. As shown in our study, some participants used *Faced* as a personalized way to learn health-related knowledge. When learning is considered, presenting all the theories, notions, and methods all at a time could be overwhelming, and providing them over time could a better way to facilitate learning, particularly when based on one's personal health as well as situated context. For example, the system can provide advice according to seasonal and weather changes or offer suggestions based on where users are located, since according to TCM theory, our health conditions will also change according to our environment. This way, it can still be used continuously as an effective way to learn health-related knowledge for those who are interested , even when one's health condition is relatively stable.

### Transparency for Reliability Assessment

Unlike other more mature and already commercialized health monitoring technologies that use quantitative measurements, such as blood pressure or body weight, the use of FRTs for healthcare is still a new emerging technology. As such, when it is taken out of the more authoritative environment of the clinic and moved into everyday life, its reliability is often questioned, especially when the results are inconsistent with the perceptions people have of themselves

This issue of reliability or trustworthiness is exactly what our participants experienced in our study. As mentioned, the underlying algorithm of *Faced* was based on a collaborations between TCM medical professionals and computer scientists; a great amount of data from local hospitals were used to train the algorithms. However, though the design of *Faced* had a rigorous scientific approach, these facts were hidden from end users and they had no clue about how the system was designed and how trustworthy it was. As such, they had no other way but their own perceptions to evaluate the results, many times leading them to question the results' reliability.

As suggested by our participants, making the underlying mechanisms more transparent, instead of hiding them from the end users, might be a way to address the trust issue. Although our findings might be biased towards the portion of our participants who were Computer Science students,

more transparency, often associated with accountability, explainability and intelligibility, has been considered as important for users to understand, trust and feel in control of intelligent systems (see [1] for a review). It is found that simply showing uncertainty or confidence level [10, 57], or just providing algorithm awareness [12] can have effects on the users' understanding of and engagement with the system. By providing them with more information or resources, it could be helpful for them to assess the results and make decisions about whether to trust the results or not, using criteria other than their own subjective feelings. Nevertheless, as any everyday health technologies, it is also important to make it clear that the use of the FRT is only for personal reference, not for professional diagnosis.

In addition to algorithm transparency, context transparency could also be considered. As shown in our study, when moving the technology from a well-controlled clinical setting to a portable platform, the variability of contextual and equipment factors also figured in ways of how people assessed its reliability. Just as our participants pointed it out, contextual and equipment variations were common, and could influence the results of the FRT. While we can take these factors into account by detecting the variations of the lighting, photo resolution, and other device features, and by standardizing the variations in order to generate reliable face reading results, we can also make these factors more visible to users so that they can understand the additional photo processing techniques and assess the results with the use of different devices.

Finally, health terminology transparency should be considered for everyday health technology. Unlike the clinical setting, where people can get professional assistance, during everyday use, people have to rely on themselves to interpret the results presented. As shown in our data, for many young participants who had a low TCM literacy, the unfamiliarity of the TCM terms kept them from engaging with the system more, despite being generally concerned with health issues and interested in using this kind of application. By making the information sources and meanings of the TCM terms more transparent (e.g. whether from some traditional Chinese classics, what they mean), and matching users' health literacy levels, the design could also help these young people to better engage with the results and effectively put the suggestions into action.

### Striking a Balance for Everyday Use

As mentioned, the use of facial images, and the change of settings made the use of *Faced* more sensitive and subject to various cultural, technical, and social constraints when compared to other self-monitoring technologies. In particular, the tongue photo taking was extremely sensitive to cultural and social norms in non-private situations [51]. As shown in our study, the majority of use of *Faced* took place in private spaces, in dormitories or at home, with participants explicitly expressing discomfort with the public tongue photo taking. This is to say, while technically, it is feasible to use *Faced* anytime and anywhere, social and cultural norms constrained where and how it could be used.

Based on our findings, we suggest that rather than making the tongue photo a required step, we can make it optional in order to bring more flexibility to the use of the system. Although the inclusion of the tongue photo can certainly increase the results' accuracy, its inclusion also introduces new constraints. By making it optional, and only using the facial photo, the results may be compromised; however, it also greatly broadens the settings where the application can be used. After all, taking pictures of the face alone is much more popular and acceptable in public. Here, a balance can be struck between less accuracy and broader usage.

In addition, where social sharing is concerned, the use of facial images is socially sensitive, e.g. fear of personal identification. In our study, some participants did not even share selfies on their social media. At the same time, as suggested by our participants, social sharing might be quite valuable in terms of providing opportunities for knowledge sharing and learning. Collecting and presenting only the necessary facial features (e.g. color, lip), and sharing health results, not in terms of the individual, but rather in an aggregate manner (e.g. 60% of people of this age at this time of the year in this area suffer from dampness-evil) might strike a good balance between privacy and sharing. This way, without revealing their personal identities, users can learn what might affect their health results, e.g. whether their recent change of health result is due to the change of the external environment, or their lifestyle.

## 7 CONCLUSION

This paper presents a study using a technology probe called *Faced* to investigate the use of FRTs for everyday health. Our study revealed some envisioned usage and also uncovered a number of obstacles to integrating it into everyday health practices. Based on our findings, we present a number of design implications such as adaptability, transparency, and a good balance. Though the technology probe was designed based on the facial diagnostic technique from TCM, we believe that our findings reveal broader implications that have value for the design of FRT-based health applications in the everyday context.

## ACKNOWLEDGMENTS

The work is supported by the National Key Research and Development Plan under Grant No. 2016YFB1001200, the National Natural Science Foundation of China (NSFC) under Grant No.61672167, and Jihua Lab under Grant No.Y80311W180.

## REFERENCES


[1] Ashraf Abdul, Jo Vermeulen, Danding Wang, Brian Y. Lim, and Mohan Kankanhalli. 2018. Trends and Trajectories for Explainable, Accountable and Intelligible Systems: An HCI Research Agenda. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, Article 582, 18 pages. https://doi.org/10.1145/3173574.3174156

[2] Yasmina Andreu-Cabedo, Pedro Castellano, Sara Colantonio, Giuseppe Coppini, Riccardo Favilla, Danila Germanese, Giorgos Giannakakis, Daniela Giorgi, Marcus Larsson, Paolo Marraccini, et al. 2015. Mirror mirror on the wall ··· An intelligent multisensory mirror for well-being self-assessment. In *Multimedia and Expo (ICME), 2015 IEEE International Conference on*. IEEE, 1–6.

[3] Amid Ayobi, Paul Marshall, Anna L Cox, and Yunan Chen. 2017. Quantifying the body and caring for the mind: self-tracking in multiple sclerosis. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 6889–6901.

[4] Hilary Browne, Benjamin B. Bederson, Catherine Plaisant, and Allison Druin. 2001. Designing an Interactive Message Board as a Technology Probe for Family Communication. (2001).

[5] Felix Cheung. 2011. TCM: Made in China. *Nature* 480, 7378 (2011).

[6] James Clawson, Jessica A. Pater, Andrew D. Miller, Elizabeth D. Mynatt, and Lena Mamykina. 2015. No longer wearing:investigating the abandonment of personal health-tracking technologies on craigslist. In *ACM International Joint Conference on Pervasive and Ubiquitous Computing*. 647–658.

[7] Gari D Clifford. 2006. Shortliffe Edward H, Cimino James J: "Biomedical Informatics; Computer Applications in Health Care and Biomedicine". *Biomedical Engineering Online* 5, 1 (2006), 61–61.

[8] Giuseppe Coppini, Veronica Chiara Zuccaia, Renata De Marià, Julie-Anne Nazare, Maria Aurora Morales, and Sara Colantonio. 2017. User acceptance of self-monitoring technology to prevent cardio-metabolic diseases: The Wize Mirror. In *Wireless and Mobile Computing, Networking and Communications (WiMob),*. IEEE, 265–271.

[9] Ciprian Adrian Corneanu, Marc Oliu Simón, Jeffrey F Cohn, and Sergio Escalera Guerrero. 2016. Survey on rgb, 3d, thermal, and multimodal approaches for facial expression recognition: History, trends, and affect-related applications. *IEEE transactions on pattern analysis and machine intelligence* 38, 8 (2016), 1548–1568.

[10] Henriette Cramer, Vanessa Evers, Satyan Ramlal, Maarten van Someren, Lloyd Rutledge, Natalia Stash, Lora Aroyo, and Bob Wielinga. 2008. The effects of transparency on trust in and acceptance of a content-based art recommender. *User Modeling and User-Adapted Interaction* 18, 5 (20 Aug 2008), 455. https://doi.org/10.1007/s11257-008-9051-3

[11] Daniel A. Epstein, Monica Caraway, Chuck Johnston, An Ping, James Fogarty, and Sean A. Munson. 2016. Beyond Abandonment to Next Steps:Understanding and Designing for Life after Personal Informatics Tool Use. 2016 (2016), 1109–1113.

[12] Motahhare Eslami, Aimee Rickman, Kristen Vaccaro, Amirhossein Aleyasen, Andy Vuong, Karrie Karahalios, Kevin Hamilton, and Christian Sandvig. 2015. "I Always Assumed That I Wasn'T Really That Close to [Her]": Reasoning About Invisible Algorithms in News Feeds. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, NY, USA, 153–162. https://doi.org/10.1145/2702123.2702556

[13] Alexander G Logan et al. 2007. Mobile phone-based remote patient monitoring system for management of hypertension in diabetic patients. *American Journal of Hypertension* 20, 9 (2007), 942–948.

[14] Darren L Walters et al. 2010. A mobile phone-based care model for outpatient cardiac rehabilitation: the care assessment platform (CAP). *BMC Cardiovascular Disorders* 10, 1 (2010), 5–5.

[15] Dena M Bravata et al. 2007. Using Pedometers to Increase Physical Activity and Improve Health: A Systematic Review. *JAMA* 298, 19 (2007), 2296–2304.

[16] Felicia Cordeiro et al. 2015. Barriers and Negative Nudges: Exploring Challenges in Food Journaling. 2015 (2015), 1159–1162.

[17] Francisco Nunes et al. 2015. Self-Care Technologies in HCI: Trends, Tensions, and Opportunities. *ACM Transactions on Computer-Human Interaction* 22, 6 (2015), 33.

[18] Jakob E Bardram et al. 2013. Designing mobile health technology for bipolar disorder: a field trial of the monarca system. (2013), 2627–2636.

[19] James Jengweei Lin et al. 2006. Fish'n'Steps: encouraging physical activity with an interactive computer game. *ubiquitous computing* (2006), 261–278.

[20] Joyce K Anastasi et al. 2014. Tongue Inspection in TCM: Observations in a Study Sample of Patients Living with HIV. *Medical Acupuncture* 26, 1 (2014), 15–22.

[21] Lena Mamykina et al. 2008. MAHI: investigation of social scaffolding for reflective thinking in diabetes management. (2008), 477–486.

[22] Rui Guo et al. 2015. Analysis and Recognition of Traditional Chinese Medicine Pulse Based on the Hilbert-Huang Transform and Random Forest in Patients with Coronary Heart Disease. *Evidence-based Complementary and Alternative Medicine* 2015 (2015), 895749–895749.

[23] Gaver, Bill, Dunne, Tony, Pacenti, and Elena. 1999. Design: Cultural probes. *Interactions* 6, 1 (1999), 21–29.

[24] Erik Gronvall and Nervo Verdezoto. 2013. Beyond self-monitoring: understanding non-functional aspects of home-based healthcare technology. (2013), 587–596.

[25] M. Shamim Hossain and Ghulam Muhammad. 2015. Cloud-Assisted Speech and Face Recognition Framework for Health Monitoring. *Mobile Networks Applications* 20, 3 (2015), 391–399.

[26] Yangyang Hu, Hong Lu, Jinhua Cheng, Wenqiang Zhang, Fufeng Li, and Weifei Zhang. 2016. Robust Lip Segmentation Based on Complexion Mixture Model. In *Pacific-Rim Conference on Advances in Multimedia Information Processing*. 85–94.

[27] Hilary Hutchinson, Wendy Mackay, Westerlund Bo, Benjamin B. Bederson, Allison Druin, Catherine Plaisant, Michel Beaudouin-Lafon, Helen Evans, Heiko Hansen, and Nicolas Roussel. 2003. Technology probes: inspiring design for and with families. In *Sigchi Conference on Human Factors in Computing Systems*. 17–24.

[28] H. Hutchinson, C. Plaisant, and A. Druin. 2002. Case Study: A Message Board as a Technology Probe for Family Communication and Coordination. (2002).

[29] Yuma Inagawa, Junki Hakamta, and Masataka Tokumaru. 2013. *A Support System for Healthy Eating Habits: Optimization of Recipe Retrieval.* Springer Berlin Heidelberg. 168–172 pages.

[30] Brielle Jaekel. [n. d.]. Sephora boosts augmented reality shopping with real-time facial recognition. http://t.cn/EGjuPZK. [Last accessed: August 29, 2018].

[31] Matthew Kay, Eun Kyoung Choe, Jesse Shepherd, Benjamin Greenstein, Nathaniel Watson, Sunny Consolvo, and Julie A Kientz. 2012. Lullaby: a capture & access system for understanding the sleep environment. In *Proceedings of the 2012 ACM conference on ubiquitous computing*. ACM, 226–234.

[32] K Kleisner, V Chvátalová, and J Flegr. 2014. Perceived Intelligence Is Associated with Measured Intelligence in Men but Not Women. *Plos One* 9, 3 (2014), e81237.

[33] Geoff Langdale, Judy Kay, and Bob Kummerfeld. 2006. Using an intergenerational communications system as a 'light-weight' technology probe. In *Extended Abstracts Proceedings of the 2006 Conference on Human Factors in Computing Systems, CHI 2006, Montréal, Québec,*

*Canada, April*. 1001–1006.

[34] Fang Li, Maylor K. H. Leung, Namisha Khanna, and Purva Satija. 2007. Online fortune telling system using biometrics feature. In *IEEE International Conference on Systems, Man and Cybernetics*. 4002–4007.

[35] Y. M. Li, H. Z. Yang, W. B. Guan, Q. S. Ke, M. Dai, H. P. Xie, and S. J. Zhang. 2008. Therapeutic effect of traditional Chinese medicine on coagulation disorder and accompanying intractable jaundice in hepatitis B virus-related liver cirrhosis patients. *World Journal of Gastroenterology* 14, 39 (2008), 6060–6064.

[36] Chang Liu, Changbo Zhao, Guozheng Li, Fufeng Li, and Zhi Wang. 2014. Computerized color analysis for facial diagnosis in traditional Chinese medicine. In *IEEE International Conference on Bioinformatics and Biomedicine*. 613–614.

[37] Deborah Lupton. 2017. Self-tracking, health and medicine. *Health Sociology Review* 26, 1 (2017), 1–5.

[38] Andrew D Miller and Elizabeth D Mynatt. 2014. StepStream: a school-based pervasive social fitness system for everyday adolescent health. (2014), 2823–2832.

[39] Francisco Nunes and Geraldine Fitzpatrick. 2018. Understanding the Mundane Nature of Self-care: Ethnographic Accounts of People Living with Parkinson's. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, 402.

[40] Kingsley C. Nwosu. 2016. MOBILE FACIAL RECOGNITION SYSTEM FOR PATIENT IDENTIFICATION IN MEDICAL EMERGENCIES FOR DEVELOPING ECONOMIES. *Journal for the Advancement of Developing Economies* 5, 1 (2016), 10.

[41] William T. Odom, Abigail J. Sellen, Richard Banks, David S. Kirk, Tim Regan, Mark Selby, Jodi L. Forlizzi, and John Zimmerman. 2014. Designing for slowness, anticipation and re-visitation:a long term field study of the photobox. In *ACM Conference on Human Factors in Computing Systems*. 1961–1970.

[42] Institute of Medicine (US) Committee on Health Literacy, L Nielsen-Bohlman, A. M. Panzer, and D. A. Kindig. 2004. Health Literacy: A Prescription to End Confusion. *National Academies Press* 15, 4 (2004), 389–395.

[43] Aisling Ann Okane, Yvonne Rogers, and Ann Blandford. 2015. Concealing or Revealing Mobile Medical Devices?: Designing for Onstage and Offstage Presentation. (2015), 1689–1698.

[44] Michel Owayjan, Amer Dergham, Gerges Haber, Nidal Fakih, Ahmad Hamoush, and Elie Abdo. 2013. Face Recognition Security System. In *International Joint Conferences on Computer, Information, and Systems Sciences, and Engineering*.

[45] A. Pantazi, A. Sebastian, T. A. Antonakopoulos, and P. Bächtold. 2008. Probe-based ultrahigh-density storage technology. *Ibm Journal of Research Development* 52, 4.5 (2008), 493–511.

[46] Enrica Papi, Athina Belsi, and Alison H McGregor. 2015. A knee monitoring device and the preferences of patients living with osteoarthritis: a qualitative study. *BMJ open* 5, 9 (2015), e007980.

[47] Stephen Purpura, Victoria Schwanda, Kaiton Williams, William Stubler, and Phoebe Sengers. 2011. Fit4life: the design of a persuasive technology promoting healthy behavior and ideal weight. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 423–432.

[48] Wang Qi. 2002. Status and Prospect of Constitutional Theory in Traditional Chinese Medicine. *China Journal of Basic Medicine in Traditional Chinese Medicine* (2002).

[49] A Radovic, C Farris, K Reynolds, E. C. Reis, E Miller, and B. D. Stein. 2014. Primary care providers' beliefs about teen and parent barriers to depression care. *Journal of Developmental Behavioral Pediatrics Jdbp* 35, 8 (2014), 534–8.

[50] Florian Schroff, Dmitry Kalenichenko, and James Philbin. 2015. FaceNet: A unified embedding for face recognition and clustering. (2015), 815–823.

[51] Leon F Seltzer. [n. d.]. What Does It Mean When We Stick Our Tongues Out? http://t.cn/EGjudme. [Last accessed: August 31, 2018].

[52] J. J. Shu and Y. Sun. 2007. Developing classification indices for Chinese pulse diagnosis. *Complementary Therapies in Medicine* 15, 3 (2007), 190–198.

[53] Aneesha Singh, Nadia Bianchi-Berthouze, and Amanda CdeC Williams. 2017. Supporting everyday function in chronic pain using wearable technology. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 3903–3915.

[54] T Tempark and T Shwayder. 2012. Chinese fortune-telling based on face and body mole positions: a hidden agenda regarding mole removal. *Archives of Dermatology* 148, 6 (2012), 772.

[55] Tammy Toscos and Kay Connelly. 2013. Designing for Positive Health Affect: Decoupling Negative Emotion and Health Monitoring Technologies. (2013), 153–160.

[56] Hitomi Tsujita and Jun Rekimoto. 2011. Smiling makes us happier:enhancing positive mood and communication with smile-encouraging digital appliances. In *International Conference on Ubiquitous Computing*. 1–10.

[57] Jhim Kiel M. Verame, Enrico Costanza, and Sarvapali D. Ramchurn. 2016. The Effect of Displaying System Confidence Information on the Usage of Autonomous Systems for Non-specialist Applications: A Lab Study. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. ACM, New York, NY, USA, 4908–4920. https://doi.org/10.1145/2858036.2858369

[58] Yonggang Wang, Yue Zhou, Jie Yang, and Qing Xu. 2004. An Image Analysis System for Tongue Diagnosis in Traditional Chinese Medicine. 3314 (2004), 1181–1186.

[59] Kiyoshi Yasuda, Noriaki Kuwahara, and Kazunari Morimoto. 2009. Remote reminiscence talking and scheduling prompter for individuals with dementia using video phone. In *International Conference on Universal Access in Human-Computer Interaction*. Springer, 429–438.

[60] Kaipeng Zhang, Zhanpeng Zhang, Zhifeng Li, and Yu Qiao. 2016. Joint Face Detection and Alignment Using Multitask Cascaded Convolutional Networks. *IEEE Signal Processing Letters* 23, 10 (2016), 1499–1503.

[61] C. Zhao, G. Z. Li, F. Li, Z. Wang, and C. Liu. 2014. Qualitative and quantitative analysis for facial complexion in traditional Chinese medicine. *Biomed Research International* 2014, 3 (2014), 207589.

[62] Jin Haia Zhou, Taoa Yang, Da Qinga Shen, and Xu Dongb Wang. 2010. Construction and application of eight principal syndrome differentiation knowledge base of tongue diagnosis based on ANN. *Application Research of Computers* 01, 2 (2010), 110–113.

[63] 张红凯 and 李福凤. 2014. 中医五脏病的面诊特征研究 (Study on Face Shape of Patients with Five-Zang Organs Diseases). In 中华中医药学会中医诊断学分会第十五次中医诊断学术年会.

[64] 张红凯, 胡洋洋, 张伟妃, 程金花, 李雪, 孙祝美, 张文强, 张磊, and 李福凤. 2018. 基于舌、面、问诊数字信息的"云中医"移动健康管理平台的建立 (Study of Yunzhongyi Mobile Health Management Platform Based on Tongue,Face and Asking Diagnosis Information). 中国中医药科技 2 (2018).

[65] 邱晓欣 and 张文强. 2015. 基于肤色和唇色的自适应面部皮肤区域提取研究 (Adaptive Facial Skin Region Extraction Based on Lip Color and Complexion). 微型电脑应用 31, 8 (2015), 1–3.