Characteristics of Socially Acceptable Healthcare Devices

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Figure 1: The set of glucose monitors that we consider for characterizing social acceptability throughout our short paper. The three participant-designed examples included were developed in our previous work [14].

Abstract

Healthcare wearables are utility-driven devices that are worn and used constantly for personal monitoring assistance, such as glucose monitoring for people with type 1 diabetes. Given the purpose of such devices, their design often emphasizes their functionality rather than their appearance or social acceptability, both of which are factors that affect their usability. In this short paper, we present an early comparison of previously-collected participant-proposed glucose monitor designs and commercially-available glucose monitors. From a form and function perspective, we highlight the differences between what options currently exist and what end-users desire. We ground our comparison in a set of four device characteristics — feedback modality, feedback audience, device form, and personalization opportunities. Through our efforts, we aim to understand how the characteristics of healthcare wearable designs impact or determine their social acceptability.

CCS Concepts

• **Human-centered computing → Human computer interaction (HCI)**; *Accessibility*.

Keywords

Social Acceptability, Healthcare Devices, Glucose Monitors.

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1 Introduction

Healthcare technologies are a subset of wearable technology devices that assist individuals with monitoring and diagnosis [10]. These devices are often utility-driven, such as glucose monitors and hearing aids, and are worn out of necessity rather than desire [8]. Such devices must typically be worn and used constantly, irrespective of one's surroundings [8, 9].

The constant use of healthcare wearables has highlighted multiple challenges for device users [5, 15]. For example, in the case of glucose monitors, prior research has uncovered three challenges. First, the aesthetics of the monitor impacts how people use the device, and how self-conscious they feel interacting with it [3, 5, 15, 17]. Second, people have very little control or choice over how they interact with their devices, like when they receive alerts [3, 5, 15, 17]. Third, devices offer limited personalization avenues for altering their device's look or function [3, 14, 15]. Few do-it-yourself opportunities exist, but they often rely on individual expertise and can therefore introduce new and different challenges when it comes to the safety of resulting solutions in practice [3, 4, 6, 14]. Generally, prior research has demonstrated that the design of current glucose monitors does not meet user needs and desires for how their devices look, feel, and function [3, 15].

In recent years, social acceptability has become a more heavily researched topic within HCI and wearables [12], particularly as wearables become more common. Koelle et al. define **social acceptability** as a scenario of interaction wherein the devices' *"presence or the user's interactions with it are consistent with the user's self-image and external image, or alter them in a positive way"* [12]. They further explain that interfaces that *"cause a negative change to self and external image show a lack of social acceptability."* [12]. Thus, social acceptability is determined by both, device users and bystanders, as it often also considers the notion of *"a lack of negative judgement"* from others [11]. Lastly, a number of factors determine social acceptability, such as device perception, device purpose, normality of the device, and the attention drawn from the device [11, 12].

While the social acceptability of wearables has been studied in HCI [11], prior efforts stop short of considering the case of healthcare wearables. Further, current efforts focus on evaluating the social acceptability of devices, rather than how we might design for increased social acceptance [13]. Healthcare wearables present a unique case study when it comes to social acceptability, given their constant, necessity-driven usage [15]. Additionally, because end-users of such devices often have limited choice regarding device use, their social acceptability also primarily concerns the device user, and less focus is placed on bystanders' perspectives [15]. Currently, we have limited guidance on how to consider such design requirements when designing new wearables for healthcare contexts.

(a) A ring that employs vibration along the inner ring for providing the user with feedback.

(b) A hairclip that employs vibration and is worn either under or over hair.

Figure 2: Two examples of participant-proposed ideal glucose monitors collected in our previous work [14].

In this short paper, we present an initial comparison of previously-collected participant-proposed glucose monitor designs [14] and commercially-available glucose monitors [1, 2]. We highlight the differences between what participants want and need from their devices, and what is currently available, using a selection of device characteristics to ground our work. We offer this comparison as a first step towards future research which will work towards considering how we can design for increased social acceptance.

2 Background

Our efforts build on prior literature relating to the current state of glucose monitors and social acceptability research.

2.1 Glucose Monitors

Glucose monitors are used by more than 8-million people worldwide to monitor and manage their blood glucose levels [7]. These devices are made up of a hardware monitoring device, a sensor which is inserted into the user's body, and often, a software companion application [1, 2]. As a predominantly self-managed health condition, individuals often seek out more personalized approaches for monitoring and management [3, 14, 16, 18]. Glucose monitors are constantly used devices, and currently commercial monitors offer limited control when it comes to factors like feedback and form [3, 14], making them a good example to consider for understanding factors that impact their social acceptance.

		Pendant	Purse	Hairclip
Feedback	Haptic	✓		✓
	Visual		✓	
	Audio		✓	
	Abstract	✓	✓	✓
	Exact		✓	
Safety	Never alerting			
	Sometimes alerting		✓	
	Always alerting	✓		✓
	On-body	✓		
	Semi-on-body		✓	✓
	Public		✓	
	Private	✓		✓
Appearance	Subtle	✓	✓	✓
	Obvious		✓	✓

Figure 3: Design space highlighting hardware, software, and context considerations covered by the example monitors we developed. Adapted from [14].

2.2 Social Acceptability

Prior literature emphasizes the need for purposefully designing for social acceptability when it comes to human-machine interfaces like wearables [12, 13], and Koelle et al. highlight the need for dedicated design and evaluation methods for addressing specific aspects of social acceptability [13]. Currently, social acceptability research related to wearables focuses on understanding what it means for a device to be socially acceptable [11, 13]. For example, the WEAR scale, developed by Kelly et al. [11], is a list of 50 questions that span ten factors, such as aesthetics, consequences, norms, and judgement, to gauge the social acceptability of a given wearable. In this short paper, we compare participant-designed glucose monitors with commercial monitors to identify differences in their design as a first step towards understanding how future devices might consider social acceptability as a driving force in the design stage.

3 Prior Work

In our previously published research [14], we conducted a study with individuals with type 1 diabetes to gain deeper insights towards what individuals' ideal monitoring devices would look like, and how they would function. Participants were free to design a wearable glucose monitor that took the form of a garment or accessory. We provided participants with a list of device requirements for consideration, as well as a physical prototyping kit. The list of requirements for consideration included things like how the device would provide feedback, what type of feedback it would provide, where on the body the device was worn, what data was visualized, and how, among others. The provided prototyping kit included materials like play-doh, a jelly bracelet and ring, a t-shirt, a scarf, pipe-cleaners, and feedback mechanism stickers, among others.

The collected prototypes from this study demonstrated a breadth of example monitors that end-users would like to have, and ranged

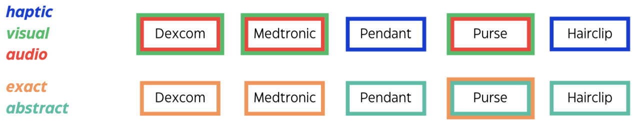

Figure 4: Options for feedback modality, where the options correspond to the sense activated by alerts and the type of data communicated, respectively.

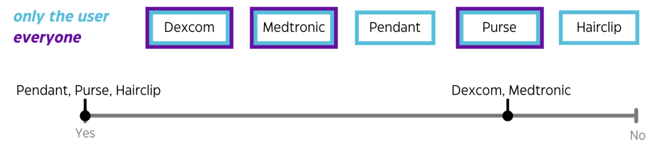

Figure 5: Options and spectrums for feedback audience, where the options correspond to who the alert is visible to and whether or not that is intentional, respectively.

across jewelry items such as rings and pendants, to accessories like hair clips and armbands (see Figure 2). Following analysis of these prototypes, our research team selected a subset of these designs (e.g., the most unique design, and the most commonly proposed design), to develop functional prototypes. As a team, we also brainstormed one additional example to prototype, with the goal of showcasing a breadth of devices across various considerations. We developed the design space shown in Figure 3 to highlight a subset of device requirements that were most considered by participants and discussed in the literature.

4 Identifying Social Acceptability Characteristics for Wearable Glucose Monitors

In the next phase of this project, we are interested in better understanding healthcare devices, like glucose monitors, through the lens of social acceptability. As such, we present an early comparison of commercially-available glucose monitors and the prototypes we developed in our previous work [14]. We consider these examples through a series of characteristics that have previously been identified as impacting social acceptability [11, 12]. Figure 1 shows the set of devices we consider.

We focus on four overarching categories of device characteristics: feedback modality, feedback audience, device form, and personalization opportunities. In the following subsections, we define each category, and explain what specific factors they encompass.

4.1 Feedback Modality

Feedback modality refers to what type of feedback is provided. Modality can be characterized by two metrics related to device alerts: what sense is activated by the alert, and what type of data is communicated through the alert (see Figure 4). The possible options for senses being activated by alerts include vision, hearing, and touch; these map to the feedback mechanisms of lights or numerical output, audio tones or chimes, and vibration or physical alteration. The two possible types of data that can be communicated are exact and abstract, where exact data provides numerical readings and abstract data provides a representation of the data, likely derived off a scale or range of some sort (e.g., a red light might mean danger, yellow might mean warning, and green might mean safe).

We found that our participants primarily opted for haptic and abstract alerts, as they were more subtle and private, and provided an easy-to-understand notification to check their data [14]. In contrast, when comparing our findings with what is possible with commercial devices, we noticed that commercial devices currently only provide audio and visual alerts through the forms of loud beeping alarms and exact numerical readings [1, 2].

4.2 Feedback Audience

Feedback audience refers to who the feedback invokes. This can be characterized by two metrics: who the data is visible to, and whether or not the alerted audience is intentional (see Figure 5). Glucose monitors either visualize data to just the device user, or to the general public that may be in the vicinity of the device user. Similarly, the design of the device and its alerting mechanisms can sometimes result in the audience of a given alert being unintentional. For example, commercially-available devices, such as those we consider in this short paper, provide one form of alerts through loud, audio alarms. These alarms are often forced, and therefore, device users cannot alter when they go off, or how loud they are. These devices, while alerting the device user, also unintentionally alert those in their immediate surroundings as a result of their modality and volume.

We found that our participants often opted for integrating feedback modalities that were more private, and therefore more subtle [14]. This shows a stark contrast from commercially-available devices, and demonstrates that the characteristic of feedback audience is directly tied to feedback modality.

4.3 Device Form

Device form refers to characteristics that define a device's physical appearance. This can be characterized by numerous metrics, but we focus on a subset that highlight: device shape and size, device notability, and device's attachment mechanism (see Figure 6). Additional characteristics that make up device form, but that we do not focus on here include on-body placement location and device weight. Each of these metrics can be categorized over a spectrum. Device shape and size range from being minimal to being bulky, and device notability ranges from subtle to obvious. We break attachment mechanism into two spectrums – 1) the extent to which the device is attached to the body, and 2) the extent to which attachment mechanisms are built into the device. Both of these operate off a variation of a yes-somewhat-no spectrum (e.g. on-body, semi-on-body, and off-body; built-in, somewhat, not at all, respectively).

When it came to device form, we noticed that while the participant-proposed examples did not always land close to one another on each of the spectrums, in each of the four highlighted metric characterizations, both commerically-available devices were placed together. This demonstrates device user's desires for alternative device forms and a willingness to experiment with and explore other options [14].

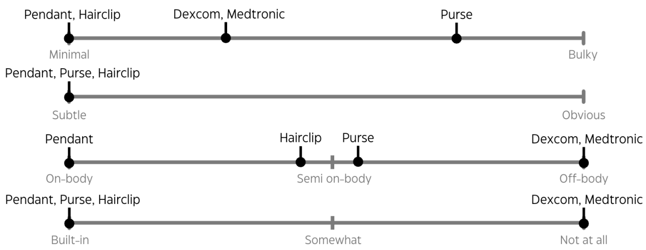

Figure 6: Spectrums for device form where the spectrums correspond to device size, device notability, extent to which the device is attached to the body, and extent to which attachment mechanisms are built into the device, respectively.

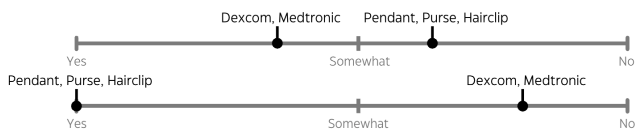

Figure 7: Spectrums for personalization opportunities where spectrums correspond to if users have control over the device's function, and the device's aesthetics, respectively.

Additionally, this further demonstrates the need for end-user input while designing such necessity-based devices to ensure resulting products better integrate individual's needs and wants.

4.4 Personalization Opportunities

Personalization opportunities refers to how much control users have over a device more broadly. We break this into two characterizations: control over function, and control over aesthetics (see Figure 7). Function encompasses what alerts are provided, how they are provided, and when they are provided, while aesthetics is more concerned with the physical form of the device.

We found that commercially-available monitors currently offer some level of control over when alerts are shared, but, they also force certain alarms and provide minimal variation in terms of the type of alert provided (e.g., they provide a very loud audio alarm) [1, 2]. In speaking with participants, this was disliked [14]. Often, participants mentioned being able to feel when they were approaching a dangerous state before their alarms rang, and found the alarms to be loud, obnoxious, and in some cases, unnecessary [14]. In terms of aesthetics, commercially-available monitors limit personalization opportunities to decoration via means such as stickers [1, 2]. On the other hand, our developed prototypes offer greater opportunities for aesthetic personalization through means such as form, colour, and decorative elements, making them more customizable and desirable to end-users [14]. When it comes to function, our developed prototypes as standalone devices offer limited options for personalization, however, when considered with an end-user driven design approach (as these were), they would offer more control towards designing for social acceptability than the commercially-available devices [14].

5 Conclusion

In this short paper, we focused on highlighting device-specific characteristics that impact the social acceptability of healthcare devices, specifically glucose monitors. We highlighted characteristics related to: feedback modality, feedback audience, device form, and personalization opportunities. We discuss individual metrics within these higher-level categories, and demonstrate how they might appear in devices through examples of commercially-available and participant-designed glucose monitors.

Our future efforts aim to continue exploring how the design of a healthcare wearable impacts or determines its social acceptability. In the near future, we plan to conduct a study wherein users are presented with a wearable and are asked to redesign it so that it is deemed socially acceptable in their eyes. We envision this study occurring as a group workshop so that we can not only gauge the user's perception of the device, but also that of bystanders. Through this study, we aim to answer research questions such as:

- What device characteristics do users want to adapt for increased social acceptability, and to what extent?
- How can we enable users to control different aspects of their devices, like how they are worn and provide feedback?
- How much control might we be able to provide users with when it comes to such device characteristics?
- When enabled, how do users want to alter their devices (e.g., hardware vs. software, form vs. function)?

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