HEED: Situated and Distributed Interactive Devices for Self-Reporting

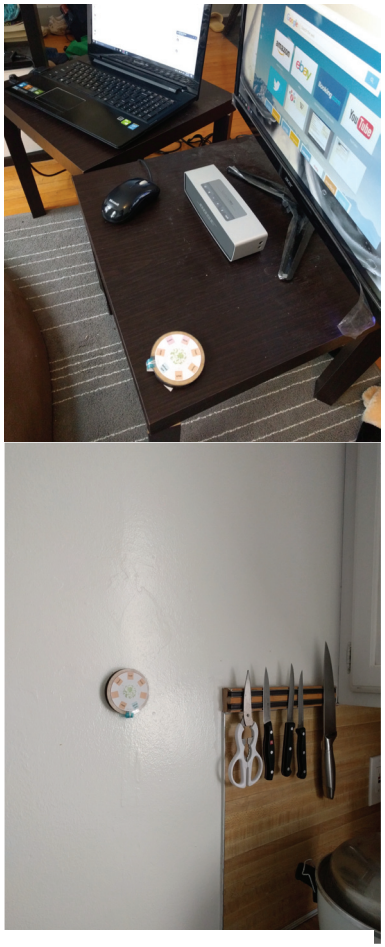

Figure 1. Devices placed by a user in (top) Office-Desk and (bottom) Home-Kitchen

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Abstract
In *situ* self-reporting is a widely used technique in HCI, ubiquitous computing, especially for assessment and intervention in health and wellness. Although, smartphones are widely used for self-reporting, there is an opportunity to design dedicated, unobtrusive and distributed self-reporting devices that improve the coverage of sampled experiences. We designed self-reporting devices for two scenarios of reporting-Activities and Stress/Sleepiness. The devices were placed by the users in their surroundings for ease of access. We show that the devices are useful especially in certain situations such as when the user is engaged in focus work. Moreover, we show that the preference of phone or devices to self-report varied between users based on multiple factors such as their engagement with phone and their preferences about being surrounded by multiple devices.

Author Keywords
Self-reporting, Experience Sampling, devices, IOT

ACM Classification Keywords
H.5.2. Information interfaces and presentation

Introduction
In *situ* self-report is called by a variety of names such as experience sampling, diaries, ecological momentary

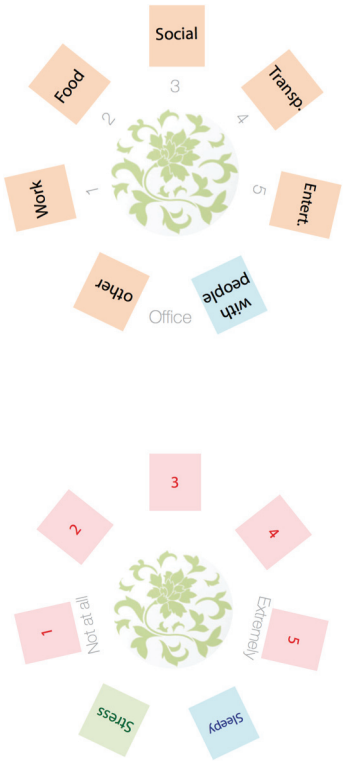

Figure 2. a) The interface for activity reporting was customized to the most common activities identified by the user for a particular location. b) The interface for stress and sleepiness reporting.

assessment or ground-truth labelling. Its popularity in the CHI and Health community is noted by its use in studies related to personal informatics, Quantified Self, lived informatics, and for self-monitoring in health and wellness.

Although, self-reporting is leveraged by various applications, it involves manual work that is known to suffer from a high burden. Self-reporting by Quantified-selfers is noted to cause fatigue, that may lead the user to abandon self-tracking [1]. Moreover, self-reporting approaches are commonly subject to the bias on the times a person can respond. For instance, if mobile phones are used, users can respond only when they are able to engage with the phone i.e. when their phone is nearby, they are amenable to phone interaction, and also they are willing to interact with the phone. Such constraints may be categorized as follows: *Specific Situations* (for e.g. a user may like to keep her phone away when she is with her family at home or other places), *Specific Population* (for e.g. a researcher may want to study mood and stress levels in children who have restrictions in place for using phones), *Specific Research Questions* (for e.g. a researcher may want to track participants' eating habits using specially designed devices that trigger the user to report just when the user is about to engage in specific activities).

We imagine the use of dedicated devices for reporting to be advantageous in two ways. First, the devices being physically present in the environment of the user would themselves serve as a trigger for self-reporting action. Secondly, preparation time, that is the time take by the user to start interaction, is a key factor in self-reporting. A high preparation time makes disruption more likely for the user. For example, preparation time is relatively high when a user has to take her phone out of the bag or pocket, unlock it and open the reporting app. On the other hand, its low when the user intends to use her phone and the unlock gesture itself serves as a report [3]. In addition to using wearables [2], one way to minimize preparation time and reduce dependence on phone engagement is to leverage dedicated self-reporting devices that allow reporting with a simple touch. We designed and developed the HEED system comprising of distributed self-reporting devices that are customized by the researchers to ask specific questions to be reported on.

Design of the HEED System

HEED system comprises of several devices distributed in the user's environment thus relying on geospatial patterns of the user, as well as users' willingness to answer questions on the device. We designed the device to have a 7-point touch interface. We found this ideal as it did not inundate the user with many choices and is also enough to support our many self-reporting questions, such as stress, and sleepiness.

The devices comprised of a microcontroller, a Bluetooth Low Energy (BLE) module, a linear touch sensor, and an LED. We used an off-the-shelf Bluetooth + microcontroller and a low-power BLE module. We used a circular soft-potentiometer. The devices were optimized for low power, going to sleep at night and after a report was made. To minimize the space requirements, we designed our own Printed Circuit Board integrating all the components in a small form factor.

We chose the form of the device to be round from a number of alternatives after successive design iterations through pilot evaluations. The design mainly depended upon the form of the touch sensor we selected. We selected a circular touch sensor as it allowed the 7 touch points to be evenly and

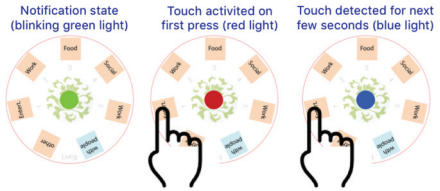

Figure 3. The states for activity reporting.

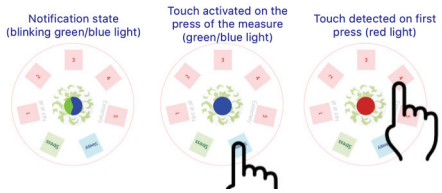

Figure 4. States for reporting on devices that were designed for stress/sleepiness reporting.

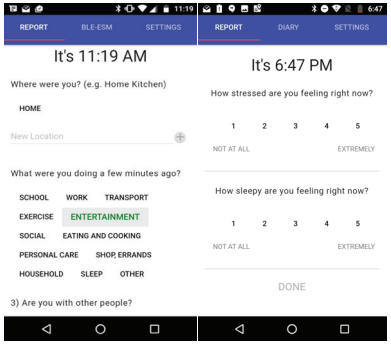

Figure 5. Screenshots of the HEED app reporting interface for activity reporting (left) and stress/sleepiness reporting (right).

symmetrically laid. We chose wood as the material enclosing the sensor because we received positive feedback during our pilot study.

The HEED devices were accompanied by the HEED mobile app. The app was instrumented to perform three fundamental tasks: collect self-reports, collect location and phone and device usage data, and manage Bluetooth devices. The devices can be customized to the research questions being studied and to the user.

Evaluation

We conducted a study of HEED devices to evaluate their usefulness in two important ways. 1) How often, throughout the day, would the users interact with devices? (i.e., what is our temporal coverage?). 2) What is the distribution of reports across the places the user visits during the day? (i.e., what is our geolocation coverage?)

We recruited 18 participants for a 1-week field evaluation of the HEED system. The study was conducted between April-June 2017 in Ann Arbor, Michigan. All participants received a notification every 45-60 minutes. Participants were divided in two groups based on the self-tracking question:

Activity Tracking: 10 participants reported their high-level activities such as Sleep, Entertainment and Work (Figure 3). Activity tracking is commonly used in time use studies. Moreover, reporting activities provides deeper insights into the situations when a device or phone was used. Participants reported 2 days on phone, 2 days on device and 3 days on either phone or device. Each participant was provided with 5 devices.

Stress and Sleepiness Tracking: 8 participants reported their stress and sleepiness levels over the course of 7 days (Figure 4). Participants were notified on both the phone and devices throughout the study.

Results

Overall, we received 581 reports from Phone and 601 reports from the devices. The difference in reports made from phone and devices varied quite a bit between participants (std=19.2) (Figure 6). We did not find a significant difference in the number of reports made from phone and device.

Phone and devices, both presented with some obvious advantages over each other. Almost all participants felt that phone was more convenient to report from while on the go or when the devices were not within reach. Similarly, almost all participants felt that when the devices were within reach and visible, the simple interaction with the device was more convenient. Almost all participants kept their phones on silent or do not disturb indicating their perception of the phone as disruptive.

Personal preference over the device-type

Participants' choice of device depended upon how they perceived their phone use. Participants who considered phone to be strongly associated with stress inducing activities (e.g. work, planning, bookings) tended to choose devices over phone. For example, P16, felt that device interaction was easier than phone- *"… my phone really serves two wildly different purposes. It's either a lot of stuff at work or a lot of stuff like casual stuff like playing video games… there's not of really in between that I do with it, as weird as it sounds. So, as I try to just kind of simplify things. Adding additional pieces to an item that holds so much weight with my work life but also kind of personal life. I try to avoid those other things that I don't want to have to do."*

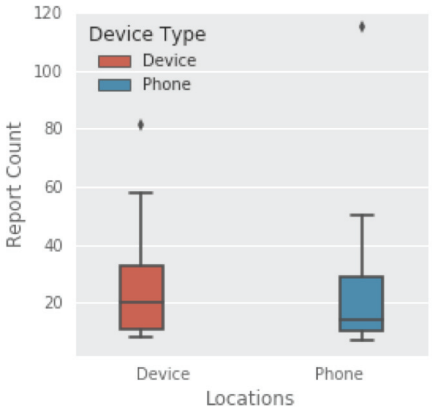

Figure 6. Overall comparison of reports made from phone and devices by each participant when using both phone and devices.

Figure 7. Locations ranked by the number of reports made.

Moreover, some participants preferred the devices over the phone feeling that the devices added significant value to their lives. P4, P14, P15 felt that interaction with devices lead to increased self-awareness. On the other hand, participants P5, P8 and P12 preferred to use phone almost always as they thought of their phone as an integral part of every aspect of their life.

Context of use (Location, Time and Activities)
From the first group (activity reporting), we observed that participants mostly used the devices in three of their top locations (Figure 7). Moreover, we found that participants found it burdensome and redundant to carry a device with them as they already carried their phones. P2 said "*I think an ideal combination would be to be able to use the phone input while out and device input when at home or at work. It's not easy to do the inputs on the device when you're either moving around to different locations often or engaging in active activities.*"

We observed that device placement had a noticeable impact on the number of reports from the devices. P3 found her device locations to be ideal and the reasons varying with the location: *"Yeah, because the one on my desk is right in front of me just below the monitor, I'm always seeing it. The one in the bedroom is right next to the bed, next to the mirror and I use the mirror, mirror and bed these are two things. Like putting stuff on my face on the mirror and go to sleep. It was in an ideal location so I always saw it. The kitchen I told you I moved so I could always see it. In terms of location, yeah, they were perfect."*

Our results indicate a good coverage over the locations and time of day as there was no significant difference in the reports from phone or devices. There were some qualitative differences observed by participants though. P5 saw phone to be used more in bigger spaces, while for devices he said "But then in my bedroom because like it's much smaller and I could see the device from almost any angle and the green light. So the device worked better in like the bedroom."

For the group which reported activities, we observed significantly more reports from the devices for activities- Sleep (T-test, p=0.01) and Food (T-test, p=0.03). It was also noted that when participants were already engaged with their phones, they mostly reported from phones. "I'm starting to think that whether I record on the phone or the device more often is mostly driven by whether I have a lot of work that day (device) or if I'm checking my phone a lot (phone). It's just whichever is more readily available."

Conclusion

In this paper, we presented a design exploration of HEED devices- distributed, dedicated and customizable self-reporting devices along with the HEED phone app. We customized and evaluated the devices in two reporting scenarios- Activity reporting and Stress/Sleepiness reporting. We find that people's use of devices depended on their perceptions about devices as well as contextual factors such as their activities and device placement.

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