Challenges, *Feedback* & *Notifications*: Empirical Explorations to Inform the Design of Interfaces to Motivate and Encourage Long-Term Personal Informatics Use

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Abstract
In our research group, we are currently carrying out several empirical research studies to inform the design of future personal informatics (PI) systems. These studies include projects investigating the use of gamification elements to encourage engagement based on a user's personality type, varying levels of feedback during day-to-day PI use, and categorizing and evaluating the suitability of dispatching PI notifications across a wide variety of wearable devices and using different feedback modalities. We provide an overview of these projects and suggest ways that our early results might contribute to the discussion of next-generation systems at the UbiComp 2015 QS workshop.

Author Keywords
Personal informatics; motivation; affordances; feedback; notifications; empirical studies; interaction design

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction

Li et al. have laid substantive groundwork for the design and study of personal informatics (PI), particularly systems that reflect facets of users' behavior back to them in order to facilitate behavior change [5]. In the Interaction Design for Information Overload (IDIO) laboratory in the Indiana University School of Informatics & Computing at Indianapolis (IUPUI), we are currently undertaking several complementary research efforts to examine interface design principles for *motivating* people to adopt personal informatics technologies and *adhere* to their use over the long term. These research projects examine three facets of PI system design: the use of gamification elements, otherwise known as "motivational affordances;" the degree to which continuous or episodic feedback is (or is not) useful for motivating PI use; and the relative value of various kinds of visual, audio, and tactile notifications to prompt or remind users to engage with PI systems.

Challenges: Examining Motivational Affordances of PI Systems

Gamified systems employ the use of motivational affordances to invoke positive, intrinsically motivating "gameful" experiences with the hope of facilitating the modification of habits or behaviors [2]. Hamari and colleagues divided these motivational affordances into ten categories: points, leaderboards, achievements/ badges, levels, story/theme, clear goals, feedback, rewards, progress and challenges.

This prior research also suggested that engagement by gamification may depend on factors such as user motivations or qualities, including personality differences [2]. A study by Codish and Ravid examined the personality traits of extroverts, based on the Big Five Model, in conjunction with individual perceptions of different game mechanisms in a classroom-based gamification setting [1]. They found several significant differences between extroverts and introverts and their preferences for various mechanisms. These results suggest that there is an opportunity to further examine individual personality traits and their relationships to the perceived usefulness of the aforementioned motivational affordances.

Based on this research literature, we developed a study to investigate whether individuals with different personality types are motivated by and respond to different motivational affordances used in gamified personal informatics applications for behavior/habit self-tracking. In our pilot study [3], we examined the following research questions:

- Which motivational affordances motivate users with each personality type to consistently track behaviors using gamified behavior-tracking applications?
- Is there a correlation between behaviors reported and motivational affordances?
- What types of behaviors do persons with each personality type prefer to report/track more often?

We recruited 35 graduate students and university employees (13 female, average age = 29.4 years) to take part in our study. We asked participants to (1) take the Big-Five personality test to assess their personality type; (2) set three daily habits (in categories such as mood, health & fitness, diet, sleep, anxiety/stress, mental health, social, or other) that they would like to inculcate as goals in the commercial

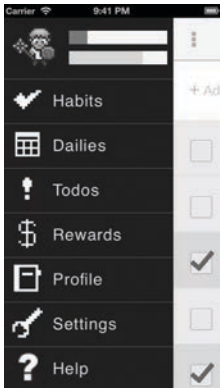

Figure 1. Screenshot of the *HabitRPG* main menu. The app includes a wide variety of gamified elements, some of which might not be optimal—or even necessary—to motivate different people.

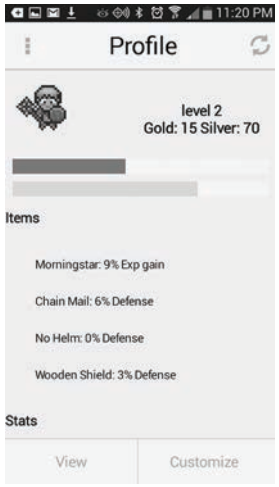

Figure 2. *HabitRPG's* display of a user's progress toward accomplishing specified goals.

application *HabitRPG*[1] (Figures 1 and 2); (3) use the application for five days and complete a survey at the end of each day; and (4) complete an exit survey at the conclusion of their participation in the study.

We used one-way ANOVAs to examine correlations between (1) Big Five traits, types of behaviors tracked *(R3),* and preferences for each affordance *(R1)*; and between (2) types of behaviors tracked and preferences for each affordance *(R2)*.

Users who tracked behaviors related to physical health (diet, health/fitness) also tracked mental health-related metrics (anxiety/stress), and users who tracked online presence also monitored mood- and sleep-related behaviors *(R3)*. Our results also showed that a PI system's affordances and, thereby, self-reflection mechanisms should vary by category of tracked behaviors (see our UbiComp 2014 poster [3] for details). Our participants reported that they preferred simple feedback visualizations related to their goals over complicated graphs to motivate behavior logging.

In our current research, we are running a follow-on study at a larger scale. In this crowdsourced online experiment, we are more rigorously examining respondents' perceptions of the usability and usefulness of each of Hamari et al.'s motivational affordances [2], when teased apart from one another. Instead of asking participants to comment on their experiences using an existing tool that incorporates several gamified elements at the same time, we created short videos that show how a web-based self-tracking tool might implement each affordance independently. We are examining people's responses to these features—and looking for correlations between these responses and the respondents' personality types—and look forward to reporting our findings in a future publication.

[1] https://habitrpg.com/static/front

Feedback: Understanding the Amount of Feedback Required to Sustain PI Use

As adoption of PI systems increases, it will also be critical for the research community to better understand how to appropriately facilitate end-user collection of, interpretation of, and reflection over their data using these systems. For example, the FitBit Flex device has five glowing dots that each light up when the user reaches a 20% goal completion interval. When the user attains their daily goal, the lights on the Flex flicker on and off and the device vibrates. While some people may value receiving these kinds of notifications, others may view them as a nuisance. With the increased use of these devices, it is important to know what kind of feedback is beneficial and how much of that particular feedback is needed.

In order to answer this question, we designed a study that controls for both the social aspect of wearable system use and the amount and type of feedback that the device provides. Both independent variables have multiple levels. The first is whether or not the participant adopts the device as part of a social cohort (or "squad") of three participants or does so alone. The other variable, the amount and type of display feedback given, has three levels: *full* feedback, *partial* feedback, or *no* feedback. In the *full* feedback phase, we allowed the participants to have unlimited access to both the FitBit website and all of the visual and tactile feedback that the FitBit device can display. In the *partial* feedback phase, we allowed participants to access the

FitBit website once a day, but all visual displays on the wearable FitBit device were blocked (e.g., display covered; vibrations shut off). The *no* feedback phase denied participants access to the website and blocked display of information on the FitBit device, itself; this condition will help us to understand whether simply wearing a device influences behavior. Every participant (in both the *squad* and *solo* conditions) experienced all three phases of the study. We employed counterbalancing to eliminate learning or priming effects that might otherwise confound our results.

A total of 24 participants were recruited from the IUPUI campus community and from other participants' extended social networks. We have worked to recruit a mix of full-time and part-time students, as well as full-time workers who are not currently enrolled in classes.

After completing a survey to collect demographic data, record previous experiences with wearable fitness devices, and establish a fitness baseline, each participant was issued a FitBit device to wear for a total of six weeks—two weeks in each of the counterbalanced conditions. At the conclusion of each two-week study phase, we administered a survey, consisting of questions such as the participants' current impression of the quality of feedback given by the FitBit device and website and whether or not the device and/or the squad members motivated the participant to be active. At the end of the third condition, a final, in-person interview was conducted to record qualitative data about the participants' personal experiences with the device and website over the entire course of the study. We also collected quantitative data about activity levels throughout the six-week study, as recorded by the FitBit device, itself.

2×6 MANOVAs will be conducted to analyze and interpret the data. In particular, we will look for any significant differences in the subjective preference ratings and in the number of steps taken across all conditions. All qualitative responses will be collaboratively coded by a team of researchers. We will look for common responses and themes that will be used to interpret the quantitative data and to better understand the range of experiences that participants had while using the overall device/website system.

Currently, we are still collecting data from participants. Our initial analysis, based on the data from our first 14 study participants, suggests a steady decline in the number of steps taken over the course of the study, regardless of what order that participants experienced each of the three levels of feedback. However, the largest number of steps recorded over any two-week period was observed in the *no* feedback phase when it was experienced first. Although this trend does not (yet) show strong statistical significance, we hypothesize that the lack of feedback about how many steps is "enough" to meet an imagined goal (without receiving any feedback to more clearly define that goal or determine whether it is being met) might lead to a higher overall activity level in an effort to set a reasonable bar for later use of the system when it is expected that more feedback will become available.

We anticipate completing our data collection and analysis for this study early in the fall of 2015.

Notifications: **Exploring the Role of Feedback across Complex PI Device Ecosystems**

We are not only examining *how much* feedback PI systems need to provide in order to be effective, but

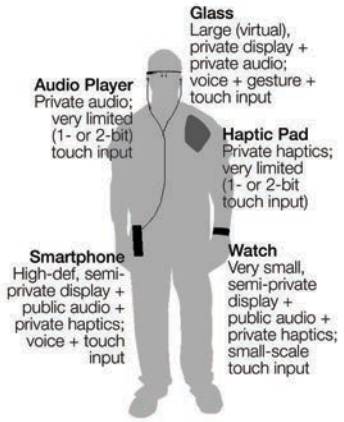

Figure 3. Devices that are part of the contemporary/emerging wearable display ecology for personal informatics.

we are also looking at leveraging the *diversity* of display devices and modalities present in contemporary wearable computing "ecologies" (e.g., smartphones, smartwatches, wearable audiovisual display devices like the Google Glass prototype [7]; see also Figure 3). Expanding the scope of notifications across multiple devices begs several relevant research questions:

- How can worn/carried devices work together to minimize *information overload*, that is, continuous demands on the user's attention, either related to an individual device or across the entire ecology?
- How can an interaction designer determine which device is the most appropriate site for a particular information display—or modality from which to expect a user's response, especially since the user may add or remove devices depending on the physical and social context (working out, attending a formal function, etc.)?

By examining both the information accessed through wearable display ecologies and developing technologies that allow these devices to work together in a more seamless fashion, we aim to advance the state-of-the-art for PI system design in the era of increased wearable computing.

In order to better understand the breadth of PI and/or "quantified self" data that will likely be handled by these kinds of systems, we are developing a taxonomy of the kinds of data that are currently collected by PI systems (and other network-connected services) and displayed to users as notifications via on-body computing devices. Given the different modalities that wearable display ecologies can use to reflect these data back to a user and the characteristics of these modalities (e.g., whether the information is shared privately, semi-privately, or publicly), we are in the midst of conducting a card-sorting activity (partially inspired and informed by a survey of information-sharing preferences [6]) to help categorize these personal informatics data based on the ways that people currently consume them—and would like to do so in the future. Our card-sorting activity is designed to help people talk about their expectations related to accessing different kinds of data without tying the discussion directly to a technology that they may or may not have actually used, to date. We anticipate that this approach will enable us to develop personas and models of information use that can help guide future interaction designs for these kinds of systems, similar to the approach that we took in previous research [8].

Based on the outcomes of this study (currently in progress; we hope to share some of our initial findings during the UbiComp workshop), we aim to develop a suite of interface proposals that enable users to more clearly specify the rules by which notifications are disseminated across their wearable display ecologies. We also anticipate being able to provide the designers of PI systems with a series of design guidelines to help them more effectively use mobile and wearable device notifications to encourage use of PI systems; for example, to remind them that it is time to log a recurring bit of data, to acknowledge met milestones, or to cue the review of progress or self-tracking goals.

New Frontiers of Quantified Self **Workshop Participation Goals**

The members of our research group share an interest in understanding the everyday use of PI technologies and in utilizing a combination of empirical and design

research to advance the state of the art in this domain (e.g., [4]). We look forward to sharing some of the early results of our studies—investigations that illustrate how the design of PI systems can be informed by research on motivation and perception. We are also particularly excited about many of the proposed topics of discussion/presentation for this year's workshop—*design techniques*, *user modeling*, *visualization*, and *long-term use*—many of which significantly overlap with the research interests of the members of our group.

About the Authors

Stephen Voida is an assistant professor in human-centered computing at the Indiana University School of Informatics and Computing on the IUPUI campus in Indianapolis. He directs the Interaction Design for Information Overload (IDIO) laboratory, where he and his students study personal information management, pervasive healthcare, and ubiquitous computing.

Yuan Jia is a Ph.D. candidate in human–computer interaction in the IU School of Informatics and Computing; Yamini Karanam is a Ph.D. student in the same program. Both share interests in the psychology of human–computer interaction and how interface design can motivate long-term technology use.

Alex Chambers, Joe Dara, Abdulaziz Alderhami, Kunal Bodke, and Dushyant Shrikhande are M.S. students studying human–computer interaction at Indiana University, Indianapolis (IUPUI).

Jessica Despard is a recent graduate from the Purdue University School of Science at IUPUI with a B.S. in psychology. She will join the School of Informatics and Computing as a Ph.D. student in HCI this fall.

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