Redesigning the Quantified Self Ecosystem with Mental Health in Mind

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Abstract
The rise of pervasive and mobile technologies has led to the development of the “quantified self" (QS) movement as a social and cultural phenomenon. Fitness, sleep-tracking, and meditation apps are just a few examples of the rapidly-growing body of QS technology. A large body of literature has outlined methodological approaches to designing and implementing QS technologies for supporting self-quantification practices. However, the implications of such rigorous and routine tracking on mental health outcomes has remained largely unaddressed in the context of the growing QS ecosystem. In this paper, we discuss the implications of current QS design approaches with respect to mental health and wellbeing.

Author Keywords
Quantified-self; personal informatics; ubiquitous computing;

Introduction
In the past decade, the public have become more health-conscious in part due to the availability of consumer-grade wearable sensor technologies and associated apps. These software and hardware tools form the *“quantified self”* ecosystem, which enables anyone to easily capture and share health-related information in daily life. Consequently, as mobile technologies are becoming more ubiquitous, people are engaging with their personal

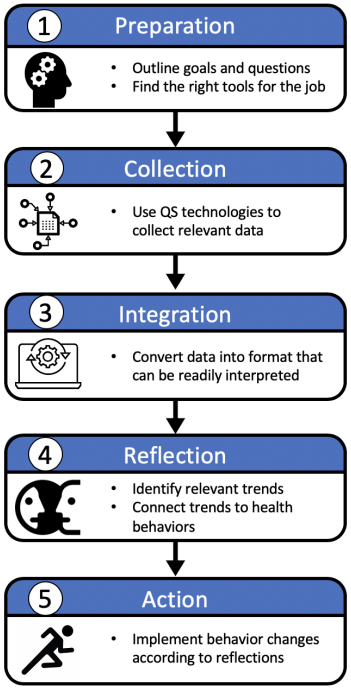

Figure 1: Adapted visual overview of Li et al.'s [6] stage-based model of personal informatics.

data more than ever. Due to recent technological advancements, there has been a significant rise in the availability of QS technologies in recent years, with well-over 160,000 tracking apps available on cross-platform mobile devices as of 2017 [7]. Due to the great potential of data collection and analysis given by apps, we can self-measure with accuracy, and modify and reflect on our behaviors. These apps help us gather data about every aspect of our lives, from what we eat to how long we sleep, and have indelibly influenced the ways in which people record, analyze, and reflect on their personal data.

Many HCI researchers have studied and documented the ways in which people integrate QS practices into their daily lives. While these studies have led to a number of insightful design guidelines and frameworks, little consideration has been given to how mental health mediates QS practices. QS technologies are typically aimed at the general population, with few safeguards in place to catch problematic patterns influenced by mental health issues [2, 10]. In this paper, we establish the connection between QS tools and mental health outcomes and discuss implications for HCI researchers aiming to expand technological ecosystems for supporting and considering mental health.

The "Quantified Self" Ecosystem

In both design and practice, QS has predominantly been conceptualized as a means of gaining insight into one's daily functioning and improving oneself based on this insight. QS tools can be used for measuring and monitoring multiple domains of health, including mental [3, 11], physical [2, 10, 4], emotional [1, 9] health.

Li et al. [6] formally outlined the process using the following stage-based model (**Figure 1**): *Preparation* (i.e. setting goals, determining what and how to track), *Collection* (i.e. collect information about themselves, such as their inner thoughts, their behavior, their interactions with people, and their immediate environment), *Integration* (i.e. transforming that data into a usable format), *Reflection* (i.e. reflecting on the data), and *Action* (i.e. taking action based on the lessons learned). However, as QS technologies have gained traction, they have diverged from the theorized stage-based model of personal informatics.

Unintended Consequences

Previous work has shown that, while QS technologies are intended to promote better health and wellbeing, incessant tracking of one's routines and bodily functions can negatively impact mental health [5]. For example, self-tracking may foster excessive self-focus. Further, the reductionist assessments used in self-tracking may motivate users to alter their behavior to suit the technology. Self-tracking may also inadvertently turn into an obligation, pressuring users to keep changing and improving despite diminishing returns.

Qualitative analyses have shown that QS technologies may instigate or exacerbate common symptoms of mental illness, such as perfectionism and obsession, and may lead to health anxiety. For instance, Baron et al. coined the term "orthosomnia" after observing an uptick in patients experiencing health anxiety over their sleep tracker data. These patients exhibited perfectionism, trying to achieve optimal sleep (as measured by their sleep trackers), and became frustrated when lab-validated measures of sleep invalidated their sleep tracker data [2]. Simpson and Mazzeo observed similar perfectionist and obsessive behavior among people with eating disorders (EDs), showing that fitness tracking was tied to ED symptomatology and expressing concern that trackers might be contributing to symptom onset [10]. Further, Costa

Figuieredo et al. observed a tendency among women tracking their fertility to become obsessed with or feel trapped by their data; these women also suffered a profound emotional toll when pregnancy remained unachievable despite data demonstrating optimal fertility [4].

Rethinking QS Technologies

Designers of QS technologies must implement systems which allow quantifying and monitoring mental health *alongside* physical, social, and emotional health. To do so, they must address factors such as data control, integration, precision, visualization, complexity, sharing/privacy, aesthetics, and user engagement [8]. Li et al. outline underlying properties of the various stages (i.e., user-driven vs. system-driven tracking, iterative stages, and cascading bariers) in their proposed model of self-tracking behavior and consequent implications for the development and design of personal informatics systems [6]. We discuss these properties and the importance of considering individuals' mental health in mitigating the risks of unintended, problematic self-tracking behaviors.

User-driven vs. System-driven Tracking

User-driven tracking places responsibility for key facets of self-tracking on the user, whereas system-driven tracking transfers this responsibility to the QS system. Designers should carefully consider the trade-offs between a user-driven approach (e.g. burden, complexity) and a system-driven approach (e.g. inaccuracies of automated analysis, loss of user control). These trade-offs must additionally account for the underlying effects of a user's mental health on their engagement with user-driven vs. system-driven interfaces (e.g. calorie tracking in weight loss vs. ED populations [10]). Ultimately, designers should seek to maximize user benefit across the health domains (e.g. mental, physical, etc).

Iterative Stages

The iterative nature of personal informatics systems suggests that QS tools should be flexible to support users' changing information needs. Since interface changes may render previously collected data useless, QS tools should support rapid iteration, so that users can quickly hone in on the questions they want to answer and select the appropriate tools to collect the necessary information. This is particularly relevant to mental health concerns, as individuals' experiences of mental health symptoms can vary both temporally and contextually.

Cascading Barriers

The presence of barriers that hinder users' self-tracking goals at each stage of the self-tracking process and the cascading effects these barriers may have in the context of longitudinal use make a holistic approach to the design of QS systems critical. Focusing only on one stage ignores the whole experience of the user with the system. However, a user's experience in one stage of the self-tracking process can change their experience of future stages and directly contribute to problematic behavioral trajectories. While developers can draw inspiration from different fields to resolve these barriers (e.g. visualization techniques from information visualization research), promoting self-efficacy within the QS ecosystem requires the consideration of all of the system's stages.

Current approaches for designing QS technologies address barriers towards promoting system use and account for the consequences of individuals' disengagement with the target outcomes of QS technologies. The QS ecosystem creates a new set of opportunities and dilemmas, with the boundaries between research, monitoring, and clinical intervention becoming increasingly obscured. Researchers, clinicians, and service users to work in a close collaborative

partnership to test the efficacy, safety, and acceptability of QS technologies with regard to the user's mental health.

Workshop Outcomes

Our work contributes to the discussion of mental health ecosystems by addressing unintended effects of the QS ecosystem on mental health. In proposing a paradigm shift in how HCI researchers design self tracking systems, we re-situate the ecosystem within an existing model of self-tracking processes [6] and make space for quantifying and monitoring symptoms of mental health alongside the other health domains. Our fellow workshop participants' collective expertise will help us refine our focus and provide a path forward for answering the following research questions: 1) What quantifiable changes in mental health levels are observed in frequent users of QS technologies? 2) Do specific domains of the QS ecosystem (e.g. fitness tracking, fertility tracking, etc.) more strongly impact mental health and wellbeing? and 3) How can QS technologies more readily account for and mitigate the risks of problematic self-tracking behaviors?

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