

Designing Visualizations of Self-Tracked Data From Bounded Situational Contexts

An Exploratory Study of Stress Data Captured During Pregnancy

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ABSTRACT

Prior studies in the physical health domain have shown how self-tracking allows individuals to better understand and improve their health by providing insight into previously invisible habits and behaviors. However, when life activities are recorded through automated or manual techniques, these activities are transformed into representations in which key contexts are often excluded. Prior research on recontextualization of self-tracked data have primarily focused on the labeling of contexts that are regularly recurring and routine (e.g. weekends) and on a micro or moment-by-moment (e.g. specific instances of physical activity) scale. However, disregarding the broader contexts in which the activities or behaviors were captured such as non-routine circumstances such as a global pandemic or life changes such as a gender transition can lead to data misinterpretation and missed opportunities to gain an understanding about the individual. In this dissertation research, I introduce and explore the concept of *bounded situational contexts*, which are contexts that are non-routine in nature. I plan on employing interviews and elicitation methods to understand how women interpret stress data captured during a specific bounded situational context, pregnancy, and participatory design methods to create, iterate, and evaluate data visualizations of their self-tracked stress data in this context. Through this research, I hope to enable designers to create representations of health data that more holistically present an individual's life events and accounts for these specific types of contexts.

CCS CONCEPTS

• Human-centered computing ~ Visualization • Human-centered computing ~ Human computer interaction (HCI) ~ HCI design and evaluation methods ~ User studies ~ Human computer interaction (HCI)~Empirical studies in HCI

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KEYWORDS

Self-tracking, health, context, data visualization

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1 Introduction

For centuries, individuals have collected data on themselves. The terms self-tracking, self-monitoring, and life logging are commonly used to refer to the act of recording one's own behaviors, thoughts, and feelings [11]. More recently, individuals have shifted from manual, active tracking to passive tracking using wearable tracking devices, an industry growing exponentially year after year [8]. Sensors enable lay-persons to systematically capture data that was previously highly burdensome or virtually impossible to collect such as the number of steps taken in one day or how much UV light their skin is exposed to over the course of the day [17, 25]. As a result of the increasing accessibility of these activity-tracking devices and applications, more individuals are leveraging these technologies as tools for health management.

When people or sensors track, events, behaviors, emotions, and physiological activities are translated into written or digital representations and most contextual information are not captured. Prior research on context-aware systems aim to incorporate various facets of context such as geographical, temporal, or social into the output representations of the events captured. However, most of these systems insert context on a micro or moment-by-moment scale, for instance number of steps taken per daily commute home [13]. They often lack representation of larger scale contexts such as life events or changes such as romantic relationship dissolution or gender transition that may have influenced the tracked behaviors [7]. I

refer to self-tracking during these specific periods of life as bounded situational self-tracking.

I define bounded situational self-tracking as tracking that occurs during a non-routine period. These non-routine periods may:

- Range on a spectrum from unexpected to expected
- Span various lengths of time
- Have a discrete or gradual end or unknown end
- End with a temporal or nontemporal trigger
- Occur once or more than once
- Be perceived as positive, negative, both, or neutral
- Conclude with a return to normal or the creation of a new normal

When these bounded situational contexts are not reflected in data representations, users of these data may lack crucial information when trying to understand their health.

Missing contextual information can lead to data misinterpretation and missed opportunities to gain self-understanding. Oftentimes, when these broader contexts are disregarded, the design and interpretation of data is defaulted to normative states. For instance, an application that is centered around recording individual foods and their associated calories but does not recognize that a user may be in period of recovery from an eating disorder, a bounded situational context, will present data that assumes that weight-loss is a desired goal [5]. While certain health conditions may follow routine patterns [20], there are others that follow stages that may be individual and unpredictable [24]. The failure to properly contextualize self-tracked data when situations are not in a normative or routine period may lead to an incomplete or inaccurate assessment of health.

Passively tracked data such as sensor data is particularly susceptible to missing context since it can be captured with no active input from the tracker. Additionally, the individual is not required to reflect as they record data, postponing meaning-making to a later point in time when the individual decides to review their data [10]. Passive tracking also enables individuals to track for longer periods of their lives – the span of years [18]. Given that these data are captured over a long period of time, they are inherently borne out of a wide range of life situations that likely include bounded situational contexts. As individuals and healthcare systems progressively rely on health information from wearable sensors, it is increasingly important to instill context back into these health data.

In my thesis, I will explore the concept of bounded situational self-tracking and the use of bounded situationally self-tracked data. I seek to understand how women perceive stress data captured by sensors and by surveys during their pregnancy, a bounded situational context, and how they envision uses for these data changing over time. The goal of this research is to deepen our collective understanding of (a) how bounded situational contexts influence how self-tracked data are used and interpreted with respect to health status and (b) how to design visualizations that

support the use of self-tracked data captured during bounded situational contexts. Specifically, my research questions are as follows:

(1) How can bounded situational self-tracked data be used for health management by self-trackers?

(1a) How do bounded situational contexts influence how self-trackers interpret their data?

(1b) What are the benefits and challenges of reviewing bounded situational self-tracked data towards an understanding of health?

(2) How do we design visualizations of bounded situational self-tracked data that support an understanding of health status?

2 Related Work

Below, I provide an overview of prior research in the field of HCI on how context is captured and used in self-tracking. I identify a gap in the current literature on specific types of contexts studied, mainly that most studies have focused on routine and cyclical contexts. Next, I briefly identify bounded situational contexts that have been previously studied by HCI researchers, though not characterized as such. Finally, I provide an overview of prior research on recontextualizing health data through visualizations.

2.1 Context and Self-Tracking

Prior research on context-aware systems have primarily focused on integrating context through individual moments as opposed to broader sets of moments, which results in relying on the individual to recall the larger scale contexts behind these moments. Context has been defined as “*a person, place, or object that is considered relevant to the interaction between a user and an application*” [1]. Through this definition, systems designed to capture contextual information often do so on brief moment-by-moment or day-by-day basis. For instance, models that predict stress often do so using an ecological momentary assessment or passive signaling capture and label stress either by the minute or by the day [9, 22]. Bentley et al created a system that analyzed individual moments and presents users with a summary of correlations such as mood and sleep [2]. While the insights provided through these systems are important, it lacks discernment of life processes occurring in the background that may be influencing the discrete moments that are being tracked, a burden which is then imposed on the individual tracker. As Nunes et al explicitly stated: “*...when seeing a slightly higher blood pressure value in a plot, the patient could try to remember what was unusual about that day that could cause such an increment*” [19]. Given that long-term tracking through passive sensing is becoming increasingly common, it is critical to design self-tracking tools that capture and present context that reflect the broader process of life experience [18].

Research on recontextualizing self-tracked data have mostly investigated routine circumstances within chronic physical illness. The contexts commonly explored are recurring (e.g. weekends or work days). Raj et al. studied how the temporal

context of “weekend” influences blood sugar spikes in a consistent repeating pattern [20]. Li et al. investigated the relationship between geographical context as measured by smartphone GPS to identify episodes of physical activity and their relationship to an individual’s *daily* schedule [13]. There exist non-routine periods of life that are critical to acknowledge when using data to assess health. While these situations have been explored in HCI literature, this is a subject largely unexplored in self-tracking literature.

2.2 Non-Routine Context and Self-Tracking

Disruptions to routine life can influence both what is tracked as well as the meaning of data that is tracked. For instance, lapses in self-tracking, periods where tracking activities have been disrupted, has been long studied in HCI and commonly framed as a loss of data [4, 12, 21]. Yet, Matthews et al. [16] found that due to the “syncopated rhythms” of bipolar disorder, the onset of an episode of bipolar disorder may lead to a struggle to self-track and thus the absence of data is meaningful in itself and indicative of occurring symptoms. In another study, Schroder et al. found that individuals that would track to manage their migraines would modify the type of information they recorded under certain stressful life circumstances. Recognizing that *non-binary lapsing* is the result of a bounded situational context could be a source of health information for individuals and their healthcare providers [23]. While non-routine life events and life disruptions are a common occurrence that has been studied in crisis informatics and social media research, to my knowledge, there have been no studies characterizing the nature of self-tracking or the use of the resulting data during these non-routine periods [6, 7]. Through this proposed research, I hope to identify the ways in which individuals make sense of health data that is captured during bounded situational contexts.

2.3 Designing Visualizations for Context

Context is used to enrich data with potential explanatory factors or trigger an individual’s memory in order to promote self-reflection [19]. This information has taken the form of photos, text, weather information, and phone activity. As previously discussed, through these methods, context is often incorporated into data visualizations on a moment-by-moment scale. For instance, photos can be used to remind individuals of what they ate *within individual meals* in order to remind them of what caused the changes in their health data. In one of the few works that develop a framework around designing for contextual data in health, Raj et al. defined the concept of contextual frames: a recurring high-level context in which different life factors have varying degrees of relevance [20]. For example, a contextual frame of summer camp can lead to a patient’s lack of access to appropriate foods and increased activity, which may lead to low blood glucose level.

Bounded situational self-tracking can be situated within this concept of contextual frames. In their discussion of design implications, Raj et al. note that (1) timescale representations of data must reflect the type of temporal cycles as determined by

users, (2) certain contextual frames may have relationships with one another, possibly reflecting a sequence which can then be used for predictions, and (3) similarities and differences between contextual frames can be used to design effective support strategies. I consider bounded situational contexts to be one type of contextual frame, but I anticipate that not all the findings about contextual frames as a whole will apply to bounded situational contexts given the lack of cyclical and routine data available and potential unpredictability. For instance, it may be difficult to find comparable contextual frames if the individual’s situational context in question is uniquely individual or infrequent, such as pregnancy.

3 Method

This dissertation research consists of a two-phase study in which I will employ semi-structured interview and elicitation methods to understand how women interpret stress data captured during their pregnancy and participatory design activities to create data visualizations of their self-tracked stress data which will then be evaluated.

To investigate how self-tracked health data collected under a bounded situational context is perceived by the trackers, in the first phase, I will conduct interviews with pregnant women to understand how they hope to use stress data that they tracked using a wearable heart rate sensor and a self-report questionnaire during their pregnancy (as part of a larger study examining pregnant women and stress). During the session, the participants will be asked to describe the ways they hope to explore the data they tracked.

In the second phase of the study, I will design and develop several visualizations of stress data based on the findings from the first phase. Visualizations of the same stress data will be presented both with and without incorporating bounded situational contextual information. I will conduct in-depth interviews with the same women from the first phase and ask them to explore each of the data visualizations and discuss how the visualizations are perceived and interpreted differently when they lack context and when they include context.

Data analysis and data interpretation as per Braun & Clarke’s Six-Phase Thematic analysis procedure, will occur during and after data collection [3]. During data collection, I will read and re-read transcripts while writing memos and formulating open codes inductively and iteratively. Recruitment for each phase will end once I achieve data saturation.

4 Results

While data collection has not begun, my hope is that the results help me refine the concept of bounded situational self-tracking. I expect to find patterns in the data on how different women hope to use their stress data and how these envisioned uses may change over the course of time as they move from pregnancy to post-partum. I also expect COVID, a different type of bounded

situational context to have its own impact as it is likely to be co-occurring with pregnancy in participants.

I also expect to see individual differences for what type of stress data is considered useful and what is less useful in gaining a better understanding of their stress levels during pregnancy. While pregnancy is only one example of a bounded situational context, in this early stages of exploring this concept, I hope to learn how self-trackers conceive of uses for their own data that was captured during this non-routine period of their lives.

Finally, I hope to develop design features or heuristics for effective communication of data captured during bounded-situational contexts in such a way that is useful to the individuals tracking towards an understanding of their health.

5 Conclusions and Implications

Current literature presents self-tracked data as if it were a permanent record of health to live in perpetuity [15]. There is an underlying assumption that the utility of the data collected is static. This research aims to investigate how the uses of data collected during bounded situational contexts may hold opportunities and challenges when compared to data collected during routine periods of life and how the uses for these data may evolve over time. In the way our identities, bodies, environments, and situations are dynamic, health data inherently reflects these diverse contexts [14]. Visualizations of health data that more holistically reflects an individual's life may enable more accurate self-reflection or diagnoses and appropriate responses.

6 Future Work

Over the course of my graduate student career, I have met and been mentored by faculty members who have served on the Doctoral Consortium and spoken highly of it. My primary goal is to receive feedback on my research proposal. Since, I will be just starting on the data collection by the time of the DC, the feedback can help me refine my methods or approach to addressing my research questions. I hope that the faculty and my peers will be able to point me to literature that I may have overlooked and offer me advice on data collection methods. In particular, I hope to learn more about various design elicitation methods that do not rely on a high level of participant data literacy. I believe that if accepted, I will come out of the DC with a stronger idea of how better address potential problems that may arise in this work.

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