Minding the Gap: Creating Meaning from Missing and Anomalous Data

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Running Header: Minding the Gap

Bio: Ciaran B. Trace and Yan Zhang are associate professors at the School of Information at the University of Texas at Austin. Trace’s research examines what constitutes a literate society and the role that people play in creating and sustaining literate environments. Zhang’s research centers on consumer health information needs and information search behavior.

Abstract: Complicating the notion that personal surveillance is always ubiquitous and pervasive, this article investigates the macro, meso, and micro level ‘gaps’ that confound the study of self-tracking. Literature from human-computer interaction, critical data studies, and archival science, as well as insights from qualitative research by the authors into the long-term value of self-tracking data, is used to expand a typology of ‘gaps’ that exist as part of the activities, behaviors, technologies, and data practices of self-tracking. In the article an emphasis is placed on elucidating micro-level accountable and expressive gaps, articulating how people respond to and make sense of the temporal absences in their own self-tracking data. In the process, the authors argue for self-tracking research to reorient from a perspective that seeks to mitigate all data gaps, to one in which data gaps are viewed as an opportunity to connect individuals with meaningful changes in the patterns of life.

Keywords: personal informatics, information behavior, quantified self, self-tracking, data studies, small data, documents
Introduction

“I’m interested for the most part in what’s not happening, that area between events that could be called the gap. This gap exists in the blank and void regions or settings that we never look at.”

One of the founders of the quantified-self movement, Kevin Kelly, has logged the devices and tracking systems that surveil the average person living in the United States, including systems initiated by individuals and external entities. As Kitchin and Lauriault describe, these technologies are enacted daily to monitor and sense the environment and to mediate the delivery of products and services. Driving habits, physical location (itinerary, movement, and presence), communication patterns, work activities, utility usage, screen activity, movements across the web, consumer purchases, entertainment consumption, financial progress, sleep patterns, health status, and physical activity are but some of the facets of a life well-tracked.

Complicating the notion that such personal surveillance is ubiquitous and pervasive, this article investigates the “gaps” that confound the study of self-tracking: a surveillance of the self with an emphasis on recording human behavior and the body’s physiology. For the purposes of typology, the term “gap” is understood in the full range of its usage, including as an absence; a lack or a deficiency; a wide divergence or disparity; an impediment; an interval or space; a discontinuity; a pause or hiatus; and as a breach, rift, or opening. An examination of the literature from human-computer interaction, critical data studies, and archival science, as well as insights from our own research on the long-term value of self-tracking data, is used to create and expound a typology of the macro, meso, and micro level “gaps” which exist as part of the activities, behaviors, technologies, and data practices of self-tracking (see table 1). Our particular contribution to the typology emanates from a qualitative study in which semi-structured interviews with self-trackers surfaced a distinct temporal aspect to self-tracking gaps along with a type of micro-level gap that we label accountable and expressive, emphasizing how people respond to and make sense of the absences and divergences in their own self-tracking data.
Table 1: Typology of self-tracking gaps

<table>
<thead>
<tr>
<th>Type of Gap</th>
<th>Description of Gap</th>
<th>Level of Gap</th>
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<tbody>
<tr>
<td><strong>Systemic Gaps</strong></td>
<td>Result from societal, economic, and technological conditions and disparities that intervene to disrupt population level activities and/or its measurement, and the extent and manner in which data is captured in the process.</td>
<td>Macro</td>
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<tr>
<td><strong>Infrastructural Gaps</strong></td>
<td>Result from efforts to obfuscate or control information pipelines that exist to demarcate and to filter select personal data traces (including current and historical self-tracking data) that flow to external actors in the private and public sector.</td>
<td>Macro, Meso</td>
</tr>
<tr>
<td><strong>Activity Gaps</strong></td>
<td>Result from differences in the broader environment and in life circumstances, which translate into disparities in daily activities and associated tracking, in turn impacting the type, temporality, frequency, and/or efficacy of self-tracking.</td>
<td>Meso, Micro</td>
</tr>
<tr>
<td><strong>Usage Gaps</strong></td>
<td>Exist due to incomplete patterns of personal use of self-tracking tools and devices in and over time. These gaps are tied to breakdowns in material assemblages and to aspects of human behavior, identity, personality, and motivation.</td>
<td>Micro</td>
</tr>
<tr>
<td><strong>Connective Gaps</strong></td>
<td>Exist as distinct intervals or breaches in self-tracking continuity caused by human and technological factors and whose effects are studied in terms of how they disrupt a person’s sense of connection to their data.</td>
<td>Micro</td>
</tr>
<tr>
<td><strong>Accountable and Expressive Gaps</strong></td>
<td>Reveal the way people perceive, account for, and make meaning from gaps that exist in personal self-tracking data. Gaps in this scenario are a pass or a way through—a mechanism by which people navigate a world where the rhythms and patterns of life create gaps in activities and associated data.</td>
<td>Micro</td>
</tr>
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Before investigating what several bodies of scholarship have to say about the gaps that characterize self-tracking, this introduction serves as background, establishing the various contexts that shape and situate systems of self-tracking at the societal, community, and individual level and foregrounding the levels of analysis mobilized in the typology. Given that the monitoring of physical activity within and across populations is a requisite form of surveillance in society today, and that monitoring levels of physical activity is a common variant in personal self-tracking, we lead with that example.6

We start from the premise that self-tracking exists as a part of a broad structure of societal measurement and of the integration of data processes and data capture techniques into spheres of everyday life. We also start from the premise that self-tracking, like much of the everyday, is “punctuated by interruptions and irruptions.”7 Instantiated in our typology of gaps is the idea that these breaks occur at and across different societal levels and thus, their impact
differs in scope and in scale. At the macro level, societal, economic, and technological conditions intervene to disrupt population level activities and its measurement and the extent to which data is captured in the process. At the meso level, more localized factors, including living and working conditions and social and community networks, influence and disorder the parameters and value of trackable activities and the self-tracking practices and data that result. The micro level is concerned with the day-to-day practice, environment, attributes, and psychological characteristics of individual self-trackers in their social settings and how these factors support or hinder how self-tracking is practiced and recorded. Here the concern is squarely on “small data,” data that is “derived from individual data traces.”

Returning to physical activity as our example, gaps at the macro level are systemic and ingrained, existing throughout and affecting society as a whole. These gaps exist as absences, disparities, deficiencies, or impediments regarding population level activity, its measurement, and any associated data that emerges from that process. From an activity perspective, increased urbanization and changes in lifestyle associated with the widescale deployment and adoption of new technologies have led to a worldwide decline in people’s physical labor and human energy expenditure. Globally, this deficit of activity is recognized as a key risk factor for noncommunicable diseases, with the result that measuring and determining rates of population-level activity is central to the health promotion efforts of policy makers and healthcare professionals.

Such population-level monitoring is a complex undertaking that depends on public health surveillance programs and on the collection, analysis, and interpretation of high-quality health and wellness data, at scale. A 2012 study by Hallal et al. utilized the World Health Organization global health observatory data repository to determine that just over thirty-one percent of adults worldwide are physically active, with figures for inactivity ranging from seventeen percent in Southeast Asia to approximately forty-three percent in the Americas and the eastern Mediterranean. Drawing from self-reported data, findings indicate significant socio-economic disparities in the prevalence of physical activity, with inactivity increasing in high-income countries and higher inactivity noted in women and in younger adults. Yet, the study also highlights the role that data gaps play in obfuscating what is intended to be a complete and global picture of human activity. As the authors note, disparities in surveillance, including the
absence of continuous surveillance systems implemented at the national level, caused lacunae across population-level activity data, with trend data scarce for most countries globally. Furthermore, the authors highlight the non-random distribution of countries from which no data is available, with data gaps concentrated in low- and middle-income countries, including those in Africa and the poorest parts of central Asia and Latin America. In addition, determining baseline population level activity was complicated by issues of data coverage and measurement quality, including concerns about the objectivity of indirect reporting measures.¹⁰

In search of ways to ameliorate the validity problems associated with self-reported data some macro-level studies have turned to technology (including self-tracking technologies capable of automatically recording people’s physical activities) as a way of directly measuring human activity. A study by Althoff et al., for instance, leveraged smartphones, and data collected from a global health and wellness smartphone app, to study disparities in the distribution of physical activity within populations in forty-six countries worldwide. Access to large-scale activity measurements using minute-by-minute step data led to a finding of “activity inequality” as a key indicator of activity disparities in a population, identifying subpopulations, including women, that are “activity poor.”¹¹ Meso-level studies have also utilized low-tech tools to directly measure activity levels within constrained or localized populations. Behrens and Dinger, for example, used accelerometers to examine steps per day in a population of college students at a campus in the central United States with the goal of ascertaining whether students accumulate enough daily steps to lead to health-related benefits. Highlighting contextual conditions, including age and specific environmental settings, that can mitigate population behavior, the authors found no significant gender differences in the daily step patterns in this population, with students surpassing the recommended 10,000 steps per day and taking part in more ambulatory activity on weekdays than on the weekend.¹²

This surveillance, measurement, technologized, and data driven approach to monitoring physical activity has percolated from the population and community level down to the consumer level in the form of personal self-tracking. In the consumer market, lifestyle, along with biological and environmental data, is actualized through active or passive capture techniques and through mechanisms that are automatized or not. The formation and configuration of self-tracking data (current and historical) is determined by the architecture of the storage platform
and its predetermined mechanisms of display. In aggregation, this transactional data is a source of “big data” for the commercial, governmental, research, and marketing sectors while also being available as micro-level “small data” for the public to do with it what they will. Indeed, the ability of the general public to keep individualized daily records of health and wellness, and the various mechanisms by which those records are kept, has expanded in recent years, with the tracking of physical activities, diet and weight loss, women’s health, and sleep being omnipresent categories in this regard.13

As self-tracking mechanisms, wearable fitness trackers and self-tracking smart phone applications fall into the category of what James Gilmore has deemed “everywear”: ubiquitous technologies that are tethered to and live alongside the body and that are designed to “make the body and its movements more knowable.”14 Yet given that the smart phone facilitates both active logging (via self-reporting) and passive tracking of information (via phone logs and mobile sensing), Vaid and Harari have deemed it the “ideal” self-tracking technology.15 The notion of ubiquity plays a key role here. As Deborah Estrin notes, “most of us mediate, or at least accompany, our lives with mobile technologies.”16 So, too does the notion of the technology’s “social capacity,” with smart phones now enabling and symbolizing an individual’s interpersonal network.17 Indeed, from a practical perspective, these itinerant, locative, and mobile forms of technology have transformed the way people communicate, connect, track, and archive their life and the lives of those bound up within their familial and social networks.

Yet systemic gaps have also been identified in the consumer driven uptake of self-tracking practices and associated self-tracking technologies. A 2016 global survey found that fifty-two percent of US online consumers had never monitored or tracked their health or fitness using any type of digital device (mobile, online, or wearable), with the over-forty age group leading in this regard.18 A French study by Régnier and Chauvel confirms the existence of a digital divide when it comes to the appropriation of self-tracking devices and notes that it exists by age and across social groups and life stages.19 Through small-scale qualitative interviewing, the authors uncovered hierarchical, dynamic, and heterogeneity factors that constitute a “social gap” in self-tracking. Their study found that affluent individuals were most likely to use self-tracking apps while individuals from lower socio-economic classes (predominantly older women) were most reluctant to use digital devices and participate in self-quantification efforts.
Indeed, social status was found to support elements that encouraged self-tracking, instantiated in people’s ability to prioritize their healthcare and in their familiarity with and access to digital technologies. Yet the authors found that the effects of social status were moderated by various cross-cutting factors including, at the micro-level, whether people had engaged in prior acts of analog or digital record-keeping around quantification and self-tracking. Régnier and Chauvel also found that mid-life changes and significant life transitions encouraged the adoption of self-tracking practices.

Intertwined with the social, economic, and cultural conditions influencing self-tracking are broader visions of health driven by stakeholder interests including the healthcare industry and technology companies. For those who do engage in self-tracking, digital forms have been conceptualized on a theoretical level as a form of “digitally assisted self-care.” Anthropologist Joseph Dumit raises the specter of a new “grammar” of health for the twenty-first century, one in which the body is considered “inherently disordered,” with illness lurking as a silent, often asymptomatic, yet ever-present destructive force in the body. As Natasha Dow Schüll notes, health has been recast from a “baseline state temporarily interrupted by anomalous moments of illness,” to a “perpetually insecure state that depends on constant vigilance, assessment and intervention.” Drawing from Foucault’s notion of biopower and the subjugation of the body, Schüll contends that one of the ways in which this vigilance is instantiated is through a mode of self-regulation deemed “data for life,” highlighting the fact that health policy and the tech sector valorize a narrative of wellness contingent upon “the continuous collection, analysis and management of personal data through digital sensor technologies.”

For Schüll, standard assumptions and sociopolitical stakes undergird such notions of digitally assisted self-care. Schüll positions digital tracking within a neoliberal worldview in which people are construed as consumers whose well-being hinges on technology assisted personal choice. In this orientation, digital tracking products aid choice by taking away human guesswork or a reliance on the immediacy of an encountered life. Instead, what is afforded is a “database self,” a self that exists and is nudged into compliance by “supplementing the myopic vantage of real-time experience with a continuous, informatic mode of perception.”

**Disciplinary Review of Self-Tracking Gaps**
“For something to become ordinary you have to become used to it, it must be part of your regular life, your habitual realm.”

Defined as “the process of recording one’s own behaviors, thoughts, and feelings,” self-tracking (or self-monitoring) as an area of research began as part of the field of behavioral psychology in the early 1970s. The academic and applied interest in studying self-tracking has since grown to encompass the medical, anthropology, sociology, and human-computer interaction fields, with mobile media scholars late entrants in this regard. Yet even with its longevity and digital newness, research into self-tracking seems to require a justification for an interest in behavior and in data that hews not only to the novel but to the mundane, the repetitive, and the quotidian.

As Pink et al. note, a study of the mundane is “an enduring theme in the social sciences and humanities.” One realm that centers and expounds the study of the everyday is cultural studies. As part of this milieu, everyday life studies articulate a field of interest in which this phenomenon is understood and investigated as a rich but overlooked site where the operation of systems of hierarchy and power can be revealed alongside the agency that people display in response to them. Operating within such systems, forms of everyday life are seen as “constructed, political, and changeable,” and imagined through a bricolage of bodily acts, material possessions, and practices. Everyday life in this instantiation is viewed as a manifestation of modernity, one that, in the case of self-tracking and the quantified-self movement, plays into systems shaped by “commodity consumption,” “bureaucratic management of space and bodies,” and by “rationalized systems of classifying and monitoring lives.”

Another realm with an interest in the everyday is human geography that focuses on the ways in which “everyday environments are experienced and configured.” Recent work by Pink and Fors centers on the notion of digital materiality and the reality that digital technologies are a fundamental part of the everyday environment that people inhabit. The authors argue that the ubiquity of digital technologies allows them to become integral to the ways in which people live, experience, engage with, and move through the world. Positioned as fundamentally spatial or locative in nature, self-tracking is understood not in terms of producing data about or from the
body but in terms of how data is co-produced in the relationship between the body, the mind, and the environment. Allied work by Pink, Sumartojo, Lupton, and La Bond mobilizes the concept of “mundane data” to explore how digital data lives in relation to “everyday routines, contingencies, and accomplishments.” Here the mundane is embraced as an inescapable part of living in today’s digital environment, as a key site through which big data is created, and as a rich domain for the study of human “creativity and improvisation.”

The study of the intersection of the everyday in relation to self-tracking, digital technologies, and data is particularly germane to the fields of human-computer interaction, critical data studies, and archival science. Their combined emphases on the study of the relationship between humans, computers, and information allows self-tracking and its digital traces to be studied in and through time as part of large societal systems, as part of the experiences and interactions of groups and community members, and as part of the life of the individual and their social settings. Building on macro-, meso-, and micro-level gaps articulated in our introduction, the disciplinary review laid out in the next section bolsters the formal typology of self-tracking gaps that underpins this article (see table 1)—a typology that will be further developed at the micro level with reference to our recent work on the long-term value of self-tracking data. Overall, the typology and associated research findings serve as an analytic tool to model self-tracking gaps at all levels of inquiry and, in the process, to articulate what it means for surveillance, including that of the self, to be understood as truly “lossy.”

Critical Data Studies

As building blocks of information and of knowledge, data are described as “the raw material produced by capturing and abstracting the world into measures and other representational forms.” In today’s digital culture, data from self-tracking falls into the quantitative mode of self-representation instantiated in numbers, graphs, lists, and various forms of spatial media. As Jill Rettberg reminds us, this mode of representation shows resilience in the length of its human history with writing first developed “not to record words and sentences but to keep accounts.” Antecedents to today’s self-tracking data exist, therefore, in document genres
that first sought to embody or record the self, including household account books, inventories, pocket calendars, and day planners.

The use of the word “data” in the English language has been traced to the seventeenth century, a development Kitchin and Lauriault attribute to the “growth of science, the development of statistics, and the shift from knowledge built from theology, exhortation, and sentiment to facts, evidence, and the testing of theory through experiment.” Yet, the formalization of a critical approach to the study of data is of more recent invention, emerging over the past decade from the work of scholars such as Dalton and Thatcher. Hastening this approach is a societal interest in emergent forms and sources of “big data”: data set apart by characteristics that include its volume, velocity, variety, exhaustivity, indexicality, and relatedness.

Through the lens of critical data studies, data is understood as existing and working within a constellation of relationships: to people, to computing technologies, and to other data and data assemblages. Adopting a human-centered focus along with a certain pragmatism towards the study of data practices, critical data studies has “problematized the expectations and value assigned to data,” probing how data is entangled with the cultural, political, social, environmental, technological, and material circumstances of which it is a part. A central remit of data studies is to examine how data is constituted in situ, tracking “the ways in which data are generated, curated, and how they permeate and exert power on all manner of forms of life.”

Drawing from critical social theory, a core concern of this community is critiquing the idea that data (particularly assemblages of “big data”) are neutral, while also undermining the sense that it is complete, pristine, accurate, reliable and self-evident, and capable of speaking for itself. A declaration is made that “data do not pre-exist their generation; they do not arise from nowhere and their generation is not inevitable.” Data is thus understood as always in the process of becoming—tied to and contingent on human activity as it cycles through often obscured processes of creation, decay, re-making, and growth.

When it comes to data generation, critical data studies draw attention to what Dalton et al. term the “problem of missing data.” This notion of “missing” data can be read on several levels, helping to populate our typology of macro- and meso-level gaps that are shown to be systemic and infrastructural in nature (see table 1). On a foundational level, Dalton et al.’s work
emphasizes the normality and the rationality of the state of data being absent. As the authors note, data production is tied to complex socio-economic factors that impact whether and to what degree a rich datasphere exists in the first place and whether data can be later extracted from a situation. When there is an implied need for data, the authors also argue that its perspective accumulation will not necessarily, or under all circumstances, “reveal phenomena and meaning that are otherwise invisible.” Thus, the authors subvert the “more is better approach” to data, which posits that the act of infilling missing data will always lead to necessary insights. For Dalton et al., the notion of missing data is also tied to the concept of “data silences,” a gap that we posit exists as part of the process of controlling or obfuscating information pipelines. At the most rudimentary level, this notion of an infrastructural gap draws attention to a preference for, indeed society’s fetishization of, data that can be commodified and monetized at the expense of that which cannot. As Iliadis and Russo note, the presence or absence of data is ultimately about power, whether it be the power to look at something and to pay attention to it or to have it remain hidden. A consequence of societal power differentials, as Dalton and his colleagues argue, is that some subaltern communities are better served by subversion, by data not being created or by data staying local, hidden, or silent.

At the micro level, critical data studies research examines the digital object as a material entity and one that carries with it the reality of breakage and repair. In our typology, this notion is represented in the micro-level categories of gaps around the usage of technology and the resulting gaps that arise in people’s connection to their data (see table 1). These ideas are particularly well instantiated and explained in Pink et al.’s concept-metaphor of “broken data.” Beginning with Lupton’s idea that data are “lively” (about life, generated in life, have an effect on life, and sustain livelihoods), the authors ponder what happens when data fails in its usefulness and utility and is seen instead as ailing or in decay. The argument that Pink et al. put forth is that self-tracking data can be broken in instances where wearables are broken, a breakage that leads to decay because it interrupts the relationship between hardware, software, data, and associated personal and data narratives. Without repair, data in this instance is seen as no longer workable; it is instead “fragmentary,” “shattered,” “cut off” and “incomplete,” characterized by “gaps” and “breaks.”
Later work by Pink and her colleagues expands the frame of “broken data” through an example of the ebb and flow in the generation and growth of personal self-tracking data. In this context, the authors reiterate that digital material breakages (of wearable self-tracking technologies and their associated hardware, software, and platforms) result in data gaps, while also highlighting a similar effect from idiosyncratic self-tracking practices, a variable we capture in the typology in the form of micro-level activity gaps (see table 1). Breakage is seen as inevitable in this scenario given that the self-tracking ecosystem of “human, bodily, sensory, emotional, environmental and other material circumstances” are rarely “predictable or reliable.” Yet the need to acknowledge and attempt to address such breakages are shown to be consequential for individuals. While Dalton et al. are skeptical of the value of data infilling at the meso level, Pink et al. acknowledge its reality and importance to self-trackers at the micro level. The authors offer up in evidence the example of one self-tracker’s improvised “data-making,” an act in which gaps in a personal data trace were physically infilled and repaired in order for the individual to construct personal meaning from it.

Using the lens of ethnography and ethnographic practice, Dourish and Gómez Cruz introduce an additional frame by which to understand data gaps, emphasizing that data is deficient or devoid of meaning without situatedness. In our typology, this understanding is folded into our category of micro-level accountable and expressive gaps (see table 1), a self-tracking gap that we expand upon as part of the research results presented later in this article. From this perspective, data does not speak for itself but must be narrated—“put to work in particular contexts, sunk into narratives that give them shape and meaning, and mobilized as part of broader processes of interpretation and meaning-making.” Rettberg describes quantitative self-representation as existing in a form that is pre- and post-narrative. The fact that it is less ostensibly “narrative” (in the way a diary is, for example), means that people must read into quantitative representations, filling in gaps that are not explicated in the story.

Furthermore, as Dourish and Gómez Cruz note, narratives or stories from data have a life of their own, used to “frame new understandings, reinforce assumptions or experiences, decenter expectations, challenge dominant narratives, reveal phenomena, hide problems, and justify decisions.” Thus, with self-tracking data has come the notion of “algorithmic visuality,” underscoring the fact that self-tracking apps render data in ways that are not as much
representations of activities embedded in everyday life as mechanisms by which people tell stories about them. This relationship between data and narrative inserts a sense of linearity and temporal fixity into a story. Yet it is one that can elide the “complexity of multiple perspectives and alternatives that live within data, and emphasize the selection of particular points of view and the de-emphasis of others.”

The fact that narrative forms are also deeply culturally grounded presages the fact that certain elements and aspects are likely present or absent in any storytelling. As Dourish and Gómez Cruz explain, stories that data support are stories already available to people, while conventions of absence can be understood as what is “traditionally left out, neglected, or placed to one side” in peoples everyday accounting of life.

**Human-Computer Interaction**

In the realm of Human-Computer Interaction (HCI), the study of self-tracking falls within personal informatics research, which, as Ayobi et al. note, can be divided into psychologically, phenomenologically, and humanistically oriented streams. Each stream brings a unique emphasis and lens to the study of the relationship between humans, technology, and self-tracking and thus of the gaps that emerge in their wake. Drawing from the fields of media studies, sociology, and digital humanities, the humanistic stream echoes critical data studies’ judicious approach to the study of self-tracking and of what we describe as the information pipelines that control the flow of personal self-tracking information to public and private sector actors (see infrastructural gaps in table 1). Overall, the humanistic approach studies self-tracking practices and technologies within the human spheres of “the self, society, and culture.”

Highlighting shifting moral imperatives, the authors describe how the weight scale of the late nineteenth and early twentieth century provided the user with access to his/her own data in a way that was externalized, direct, and easily reflected upon. In contrast, today’s wearable devices are
understood as operating within a system of hidden imperatives, with the goal of making the user “known to a range of other parties” often foreign to the self.\textsuperscript{61}

In effect, the complexity of data today is seen as tied to its multi-directional flow—“between devices, consumers, companies, institutions, social networks and back again”—and concomitantly by its use by a wide variety of actors, including intermediaries.\textsuperscript{62} Here, the notion of a self-tracking gap is tied to a deficiency in understanding: the lack of a person’s capacity to understand an information infrastructure and its entangled mass of data relationships that exist beyond an individual’s sphere of influence. As Crawford and her colleagues state, there are “layers of obfuscation” about what is subsequently done with data and for what purpose, an outcome that is “ultimately at the company’s (rather than the customer’s) discretion.”\textsuperscript{63}

Informed by “behavior change strategies and psychological theories,” the cognitive or behavioral psychology framework is invested in the study of the individual and how to “design more effective and efficient personal informatics systems, with reflection and self-knowledge as central concepts.”\textsuperscript{64} The emphasis of this research frame makes it particularly suitable for fleshing out micro-levels gaps that occur around the usage of technology and the resulting connective gaps that arise in people’s connection to their data (see table 1). If Pink et al.’s work sheds light on these micro-level gaps from a critical data studies perspective, the work of Li, Dey, and Forlizzi brings a cognitive perspective to the analysis.

With the design of persuasive technologies in mind, Li, Dey, and Forlizzi model the mental processes that accompany people’s interaction with personal informatics tools. Problems that emerge during the stages of preparation, collection, integration, reflection, and action are viewed as cascading “barriers” to behavior change that are driven by the user, the data, and/or the technology. In this viewpoint, gaps in self-tracking are understood as unwanted features of the various psychological stages that typically manifest as intervals, spaces, pauses, discontinuities, or breaches in self-tracking and/or the data that emerges from the process. Providing examples, the authors note that a user preparing to change self-tracking tools needs forethought to avoid data abandonment and associated data gaps. In the collection phase, lack of time and motivation as well as forgetting to track in the first instance, are considered other user driven issues that may result in data gaps. Data gaps are also understood from a technological perspective, viewed as a hazard of systems designed with complex multi-faceted collection
stages in mind. Concomitantly, the authors establish that in the reflection stage, the gap is primarily focused on an interruption of meaning making, with such work hindered by data scarcity and a lack of context to the data, among other concerns.\textsuperscript{65}

In harnessing Rooksby et al.’s perspective that people’s motivations for self-tracking extend beyond action-oriented and goal-driven behavior change, Epstein et al. build upon and clarify the “stage-based” model described above.\textsuperscript{66} With a nod to Rooksby’s “lived informatics” model of self-tracking, Epstein and his colleagues investigate an expanded set of motivations and behaviors for self-tracking across different domains. In seeking to understand what motivates self-trackers and thus to understand their use patterns, Epstein et al. establish the baseline factors that people identify as impacting their physical activity levels.\textsuperscript{67} Their findings help flesh out the nature of micro-level activity gaps (see table 1), which the authors tie to concrete causes both internal (injury, fatigue, sleep amount and quality, stress and mood, and food consumption) and external (variations in work schedule, poor weather, travel, changes to daily schedule, schedule of family members, socializing, deviations to routines) to the individual. The notion that people experience “abnormal” days (days in which there are changes to schedules and routines) highlights the role that community and the environment play in how activity and data gaps are manifested in space and time.

Epstein et al.’s lived informatics model also adds to our understanding of self-tracking gaps by surfacing the notion of lapsing (temporary, longer-term, or permanent), which, along with “streaks” (an uninterrupted period of use days), exist as distinct temporal rhythms of activity tracker use and nonuse.\textsuperscript{68} Manifested through forgetting to use self-tracking tools, failure or difficulty in managing their upkeep, intentionally skipping the logging of entries, and purposefully suspending tracking during a set time period, Epstein et al. tie these lapses to human behavior, to constraints imposed by time, and to (the human need for) technological turnover.\textsuperscript{69} Taking the same temporal perspective, Tang and Kay also relate the notion of incomplete data to differing regimes of wearing behavior, recognizing that individuals show distinctive patterns of “adherence” as well as “breaks” from wearing self-tracking devices. In a nod to our category of micro-level accountable and expressive gaps (see table 1), the authors note that participants were able to “reflect on these days in terms of the reason and the context behind non wear as well as what these gaps meant to them.”\textsuperscript{70}
In the critical data studies literature, the notion of broken data has drawn researchers to study the human labor involved in attempting to overcome such data breakdowns. This tranche of HCI work takes a similar approach, albeit with an overt focus on data gaps as design issues to be surfaced and solved. The specificities and ramifications of the HCI research shows that sparse data often leads people to struggle to figure out its meaning and ultimately to abandon self-tracking tools and devices.\textsuperscript{71} Yli-Kauhaluoma and Pantzar describe how “connective gaps” (see table 1) surface on occasions when an individual’s sense of and search for connectivity in their everyday experience is not supported by their self-tracking data. Echoing Pink et al.’s articulation of “broken data,” the authors situate connectivity gaps as voluntary or involuntary forms of disconnection that lead to “invisible,” “fragmented,” “inaccurate,” and/or “uninterpretable” data streams and that hinder an individual’s ability to engage with and reflect on their data. The effect is to leave people feeling confused, indifferent, and disappointed with their data.\textsuperscript{72} Rapp and Cena’s study of people new to self-tracking tools (consumer devices and mobile apps) shows that it is both human (issues with forgetfulness and an individual’s lack of time, motivation, opportunity or know-how) and technological factors (issues with affordances including practicality, aesthetics, and operation) that result in incomplete and thus less accurate, reliable, and trustworthy data.\textsuperscript{73} From a design perspective, Packer et al.’s work highlights the fact that in seeking to overcome the gaps caused by idiosyncratic human behaviors and imperfect technological affordances, people support the use of interfaces that could correct, replace, and annotate data and that could compare and infill data from other devices.\textsuperscript{74} Rapp and Cena and Epstein et al. reorient the argument from an examination of forms of connection and disconnection to data to a broader examination of the difficulties that living and working with data entails. Centering the notion that data can be burdensome highlights rationales for abandonment other than incompleteness. Here, reasons for abandoning self-tracking include the encumbrance associated with collecting and integrating data, the personal ramifications of having or sharing data, concerns for data quality, discomfort with the information revealed by the data, a lack of emotional and immediate connection to data visualizations, difficulty in exploiting gathered data, and diminishing returns in terms of insights gathered from it.\textsuperscript{75} The relationship between lapsing, abandonment, and data issues is further refined by Jarrahi et al. who demonstrate how the information features or affordances of self-tracking
devices work together with a person’s activity levels and pre-existing motivations to form self-tracking types. “Aspiring starters” and “motivation seekers” used the informational and motivational affordances of their devices in tandem to achieve long-term effects. Undermining the notion that “better data sources, or better presentation of information from activity-tracking devices, motivates user behavior change” were the “curious immobiles” and “persistent roamers.” For these styles of self-trackers, the information affordances of the device cycled through short-term relevancy to redundancy and, when accompanied by a lack of motivated interest, crippled long-term use. It was only those categorized as “quantified-selfers” that showed long-term engagement with the informational affordances and outputs of their devices.

In Ayobi et al.’s review of the phenomenological tranche of the personal informatics literature, this research stream ties use and non-use of self-tracking devices (activity and usage gaps in our typology) to well-trodden individual and contextual factors, such as “motivation, expectations, expertise, tracked activities and choice of tracker, as well as personal living conditions and changes in life.” Yet in contrast to the psychologically oriented viewpoint, the phenomenological approach eschews notions of technological efficiency and effectiveness to study “how wearable self-tracking technologies are used and experienced” and, in the process, focuses on the “the interactional, emotional, and social dimensions of tracking practice.” Indeed, “socially enculturated” is Lupton’s description of how individual’s reasoning and motivation to self-track is influenced by broader social contexts and relations.

From the perspective of self-tracking gaps, Clawson et al.’s work helps to provide a more exhaustive rationale for people’s abandonment of health-tracking technologies. These include so-called “productive” reasons (e.g., goals being obtained, technology being upgraded), along with rationales related to social environment (e.g., peer influence) and changes in physical abilities (e.g., due to health status). The authors note that the most common rationale for abandonment was a mismatch between the user’s expectations and the capabilities or affordances of the self-tracking device. Lazar et al. note an additional rationale for abandonment—when the marketing and branding of a self-tracking device fails to align with an individual’s personal identity or perception of self. While abandonment can thus signal a failure on the part of the technology to meet or to adapt to various underlying human needs, several authors, including Clawson et al., argue that gaps in use can also be a harbinger of success. As Nafus and
Sherman note, for some self-trackers, the fact that a habit or pattern is successfully internalized means that external interventions are no longer seen as necessary. 84 This is an example of “happy” abandonment, as noted by Schwanda et al., an insight that clarifies that “successful” technology usage should not always be measured in terms of persistence or longevity. 85

From the phenomenological perspective, this notion of durability has also been investigated in terms of how people live with and alongside their self-tracking data over the long-term. The importance of this research from the perspective of our typology is that it delineates the documentary nature of some self-tracking practices, highlighting the space in which accountable and expressive gaps operate (see table 1). If Li et al.’s work situates people’s reflection with current and historical data as part of their process of behavior change, 86 Rooksby et al.’s notion of documentary tracking acknowledges that reflection can be an end in itself. As the authors state, “knowing oneself may involve collecting and reflecting on information about oneself but is for the purposes of a life being lived.” 87

Documentary tracking includes people’s need for and reflection on what Elsden and his colleagues call a person’s “quantified past.” 88 As Elsden et al. state, “documentary tracking is not simply a way of creating copies or impressions of reality, but is also a means of communicating personal narrative, identity and a felt sense of self (selfhood).” 89 The notion of “rhetorical data-work” is used here to describe the manner in which people can appropriate historical data to “form highly personal accounts of their pasts.” 90 In seeking to help people make an account of their historical data, Elsden et al. warn against the fallacy that more or better data is necessary to achieve this. Yet cognizant of the gaps that exist in peoples self-tracking data, they foreground the research results laid out later in this article by calling on researchers to study how people perceive and interpret these gaps and how they are explained or compensated for. 91

Archival Studies

Like critical data studies and human-computer interaction, archival scholarship is also invested in the study of information “gaps” and “silences.” 92 Tied to a discipline and to a profession, this literature emphasizes absences (and their consequences) as manifested throughout the lifecycle of those records that will or should become the source material of
history. Records in this instance, whether analogue or digital in nature, are information forms whose distinguishing feature is their ability to provide ongoing evidence of human processes and activities. Historical examples of analogue self-tracking records have found a home within institutional archival repositories including at the Louise M. Darling Biomedical Library at UCLA, which houses a collection of over 1,300 nineteenth- and twentieth-century baby books containing parental records monitoring the mental and behavioral development of their infant children. While the idea of the long-term value of digital self-tracking data has clearly been articulated in the HCI literature, the lag between the creation and the archiving of societal data means that the centuries old archival profession has only just begun to examine the value and possibilities of preserving the new regimes of recordkeeping characteristic of an individual’s online, networked, and mobile life from the 1990s to today.93

As “an enduring form of information infrastructure,” an examination of the archive as pipeline and as conduit helps to understand the absences that occur as information flows through time and space from a creator to a public for external and continuing consumption and use (see infrastructural gaps in the typology in table 1).94 An overall framework for such absences is articulated by anthropologist Michel-Rolph Trouillot who contemplates the key moments in which silences can be introduced into the historical record: “at the moment of fact creation (the making of sources), the moment of fact assembly (the making of archives), the moment of fact retrieval (the making of narratives), and the moment of retrospective significance (the making of history in the final instance).”95 Siding with work in critical data studies, Trouillot’s work emphasizes the purposeful nature of silences, declaring that silence is “an active and transitive process. . . One engages in the practice of silencing.”96 Indeed, archivists are aware of the fact that the archives they create (process, store, manage, and preserve) are, at best, partial and fragmentary traces of the functions and activities of an organization, a family, or a person as they existed through space and time. It is an admission on the part of the profession that physical aggregations in the archive are a direct result of “human decisions about selection or co-location.”97

A distinction is thus made in the archival literature between the incomplete physical realization under archival control and a broader conceptual abstraction (the *fonds*) that represents the entirety of an entity’s documentary trace independent of aggregation or length of survival.98
As Trace has described, the notion of archival control is also moderated by the fact that the flow of information between the creator, the archive, and the subsequent user is discontinuous and disrupted, with a backlog of unprocessed collections interfering with the distribution and consumption end of the knowledge process. Whether attributed to social and political constraints on the funding of cultural heritage institutions or the systematic failure on the part of the archival profession to adapt to a technological and information-dominated society, the backlog creates a critical gap in archival infrastructure and a prevailing sense that interruptions in the information pipeline are the norm in the archive.99

When it comes to the moment of fact assembly and retrieval, the long tradition of differential representation in the archive bolsters the regrettable notion that benefits accrue only to those who operate in society within a frame of reference acceptable to dominant groups. As archivist Rodney Carter states, power is tied to the human capacity to “make lasting statements that will be heard and attended to,” while marginality equates to voices that are non-conforming and thus silenced or ignored.100 Resonating with the critical data studies literature, the notion of absence instantiated in the archive is understood as systemic and structural in nature, at the discretion of those with status and influence in society and arising through processes of destruction, manipulation, and exclusion.101 The literature clarifies that archival silences exist to enhance certain narratives in society while eliding the recollections, memories, stories, commonalities, identities, and histories of others.102

Archivists have turned to theorists such as Michel Foucault, Jacques Derrida, and Jean-François Lyotard to understand how silences enter the archive and the methods by which they can be read, understood, and unraveled. Carter’s work of interrogating silences draws from postmodernist as well as feminist theories that treat the record and the archive as sites of examination. In such a framework, the researcher is tasked with examining texts with an eye to naming omissions and lacunae and resisting dominant narratives of an archive by reading against and along its grain. Seeking to fill in the gaps, Carter highlights strategies of intervention and reanimation in the processes of record creation and documentation, strategies that may be attuned to needs and wishes foreign to the archival profession. Indeed, like Dalton et al., Carter acknowledges silence as an apposite choice for some record creators, describing how its invocation “can be a strategy used by the marginalized against the powerful.”103 Silence is thus
understood both as an unnatural absence of information and as a natural “forceful strategy of resistance,” a form of communication that is consequential whether recognized by other actors or not.¹⁰⁴

Other forms of archival silence manifest in various forms of privileging that, as already alluded to, have been baked into the development of theories and methodologies within the archival discipline. These forms of privileging have resulted, as Trace and Zhang note, in a multitude of “possibilities for archival practice” being largely overlooked or ignored in the now emergent born-mobile space.¹⁰⁵ The first thread of that gap involves a tradition of centering official and organizational records that emerge under conditions of capitalism at the expense of personal records that are generated as part of the social sphere, a type of “othering” present since the birth of modern archival science in the early twentieth century.¹⁰⁶ Focused on differing notions of how to value records, a dichotomy has arisen that pits concerns for the transactionality, methodicalness, collectivity, expansiveness, and pragmatism of information on the one hand and concerns for its subjectivity, personification, disorderliness, individuality, boundedness, and emotionality on the other.¹⁰⁷ The creation of a more nuanced theory of the personal is an attempt to address this silence, moving personal records firmly into the archival research glow. In this milieu, Catherine Hobbs highlights the psychology of archives: the claim that personal records attest to the “inner, more intimate aspects of human character.”¹⁰⁸ Here the transactional and informational value of records is set aside to center their narrativity. Comparable to a critical data studies approach, personal records are understood as “creations of the self,” records that “participate in a process of storytelling and de facto autobiography—of the self presenting or representing the self.”¹⁰⁹

A second thread of this archival silence involves a concentration of extant archival scholarship that, as Amelia Acker demonstrates, shows an implacable allegiance to defining the record in the digital environment according to frameworks drawn from traditional understandings of analog records and recordkeeping systems.¹¹⁰ This despite the fact that, as Charles Jeurgens notes, the outputs of technologies of communication have transformed from discrete, recognizable, and bounded digital objects to unremitting streams of data from which different aggregations can be constituted.¹¹¹ If, as Moss et. al state, “archives will no longer be conceived of as collections of texts, but as data to be made sense of,” then addressing this gap
requires the adoption of an infrastructural view.\textsuperscript{112} As Acker notes, this involves taking a holistic look at emerging digital formats, their associated mobile computing systems, and the complex networks in which data traces are created, circulated, and stored. Of central importance here is the study of the material constraints and conditions of electronic communication—that is, materiality understood as including the “physical form (however atomic the bits)” while also extending to “the systems, practice, and social institutions that are built up around artefacts.”\textsuperscript{113} This move from a predominantly documentary view of the world to that of a more data oriented one, and the critical reframing of theory and practice that this should engender, argues for a greater alignment between the archival profession and scholars working within the field of critical data studies.\textsuperscript{114}

**Method**

This section introduces select findings from our qualitative study of self-trackers that uncovers novel insights into how people perceive and understand self-tracking gaps, thus fleshing out the typology at the micro level. The study did not initially set out to explore the “gaps” that confound the study of self-tracking, but arose from an interest in understanding the long-term value of personalized collections of quantified-self records, studying those who had integrated self-tracking practices and apps into their daily lives over an extended period. Using semi-structured interviews as a data source, our interest was in establishing how the conduct of everyday life was mediated by self-tracking data, tools, and methods; the meaning that individuals assign to self-tracking data across their lifetime; and how design should support the long-term personal use of self-tracking data, as well as the subsequent archiving of self-tracking data for broader societal purposes.\textsuperscript{115}

One of the published findings from the study was that various forms of partialness challenged participants’ belief that their lives or self-tracking data had meaning or a justifiable presence in the archive. Partialness implied that some types and forms of self-tracking data were seen as too self-centered, insipid, incomplete, unintentional, or poorly narrativized to warrant a place in the broader historical record. Yet in spite of such misgivings, participants were able to articulate ways in which their “archived self” would have long-term value in a public setting, a
situation most evident when data was thought of holistically, longitudinally, and interconnectedly.\(^\text{116}\)

Indeed, in the process of analyzing participant accounts of the arc of their own self-tracking practices, themes surrounding the generation and accumulation of self-tracking data repeatedly emerged in ways that were distinctly temporal and richly personal and narrative in scope. The normality and ubiquity of lives characterized by a duality of processes and traces that modulated between absent and present—and everything in between—encouraged us to revisit the semi-structured interviews to further investigate the role and meaning of micro-level gaps in self-tracking. It is these aspects of self-tracking that are pulled out and analyzed here.

As mentioned, the data that forms the basis of our study is drawn from semi-structured interviews. Prior to participant recruitment, human subjects approval was sought and obtained through the university’s institutional review board. Recruitment of research subjects took place from mid-October to the end of December 2017 via a university listserv for faculty, staff, students, and alumni, accompanied by a snowball strategy that encouraged participants to share study details with relevant parties. To qualify to participate in the study, a participant needed to have used a smartphone app to track their health, wellness, or fitness (e.g., diet and weight loss, physical activities, women’s health, and/or sleep) for at least six months and be eighteen years of age or older.

Eighteen people (ten females and eight males) between the ages of eighteen and forty-two participated in the study. At the time the study was conducted, seven were undergraduate students, six were graduate students, four worked in administrative roles, and one was a research scientist. Most (fourteen) of the participants were white (three of whom identified ethnically as Hispanic or Latino), with the study also including Asian (three) and African American (one) participants. Annual household income varied: eleven lived in households that earned less than $49,999, three lived in households that earned between $50,000 and $99,999, and the remaining four participants lived in households earning more than $100,000 a year.

All eighteen participants had tracked some aspect of their health and fitness, as it was a basic criterion for participating in the study. Other areas that saw a preponderance of tracking included personal finances (13 participants) and body and medical symptoms (11 participants). The criterion for participating in the study also meant that, at the time of the study, all
participants were tracking using smartphone apps, most prevalently Apple Health, followed by Fitbit, MyFitnessPal, Nike+Run Club, and Samsung Health. The longest time any participant reported using one of these apps was six years. Participants also utilized other digital means of tracking, including integrated smartphone features, dedicated hardware/wearables, computer desktop applications, web-based services, digital calendars, web-based applications, and online/digital diaries or journals. Tracking was carried out solely by digital means in only two cases. More typically, digital tools were part of an ecosystem of self-tracking across a person’s lifetime that also included mental (two participants), analogue (four participants), or analogue and mental forms of tracking (ten participants).

The study protocol required participants to complete an online questionnaire that gathered demographic data and basic characteristics vis-à-vis self-tracking behavior (e.g., what participants tracked and for how long), as well as their experience in using self-tracking apps (e.g., motivations and barriers in the self-tracking process). In-person semi-structured interviews were scheduled upon completion of the survey. Participants were asked to bring their smartphones (with installed self-tracking apps) and any analogue tracking tools to the interview. During the interview, the researchers took pictures and/or screen shots and short video clips representing the participants’ self-tracking practices. The interview questions were grouped around two main topics. The first set of questions invited each participant to consider their self-tracking practices across their lifetime. This discussion was facilitated through a self-tracking timeline created by participants during the interview as part of the elicitation process. In the second set of questions, participants were asked to consider a scenario in which their self-tracking data crossed a personal and familial boundary by being acquired and preserved in a public archival repository. Interviews ranged from 44 to 153 minutes in length (with a mean of 72 minutes). Upon completion of the interview, participants received a thirty-dollar gift card.

Table 2. Participant characteristics and self-tracking history

<table>
<thead>
<tr>
<th>Participant</th>
<th>Self-Tracking History Across Childhood, Adolescence, and Adulthood</th>
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</thead>
<tbody>
<tr>
<td>P1 F, 27, graduate student</td>
<td>8-9, daily events/13-15, moments/occurrences (paper, journal)</td>
</tr>
</tbody>
</table>

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<td>Participant</td>
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</tr>
<tr>
<td>-------------</td>
<td>---------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| **P2**      | **F, 25, graduate student**  
observations
(paper, journal)  
graduated school, women’s health, exercise, meditation (digital, Clue), finances (digital, Mint, spreadsheet)  
Pre 10, personal reflections/crashes (paper, diary)  
Pre 18/high school, menstruation (digital, iPhone app)  
18-23, events/experiences (paper & digital, diary); 21-22 [undergraduate, year abroad], health & fitness (digital, MyFitnessPal); 23 onwards [graduate student, gifted a Fitbit Flex, moved in with partner], health & fitness, weight (digital, MyFitnessPal, Couch to 5k, Fitbit, Google Fit), finances (digital, Splitwise, spreadsheet) |
| **P3**      | **F, 28, academic advisor**  
24 [graduate school], thankfulness (paper, journal); 26 onwards [gifted Fitbit, desk job after graduation], health & fitness (digital, Fitbit) |
| **P4**      | **F, 19, undergraduate student**  
17 [international exchange student], events/experiences/cultural differences (paper, journal)  
18 [backpacking trip], daily details (paper, journal); 18 onwards, health & fitness, menstruation (digital, Clue, Apple iPhone Health), finances (digital, bank app), life events (digital, Journal, Day One), travel (digital, App in the Air), weather (digital, weather app) |
| **P5**      | **F, 39, student advisor**  
12-14/middle school, events/experiences at home (paper, log/journal)  
24-25, events/experiences (digital, online blog); 29 [finished second graduate degree, moved back to home town] onwards, finances (paper; digital, apps, spreadsheet); 34 onwards [health condition], health & fitness, treatment & medication, weight (digital, MapMyFitness, Omada)  
17-23 [dad sick, dad died, college, switching schools], events/experiences (paper, journal) |
| **P6**      | **M, 22, graduate student**  
18/twelfth grade to 21 [new smart phone, college], health & fitness, heart rate, weight (digital, Fitbit); 18/twelfth grade onwards [college, living with roommates], finances (digital, Splitwise), location (digital, magicpin), weather (digital, AccuWeather); 21 onwards [new smart phone], health & fitness, heart rate, weight (digital, Samsung Health) |
| **P7**      | **F, 23, graduate student**  
14-18/through end of high school, menstruation (digital, app)  
20 onwards [undergraduate, international study abroad], sleep (digital, Sleep Better); 21 [college], health & fitness (digital, MyFitnessPal); 22 [graduated college, started a job] onwards, health & fitness (digital, MapMyRun); 23 [started graduate school] onwards, finances (digital, spreadsheet, You Need A Budget) |
<p>| <strong>P8</strong>      | <strong>8/third grade onwards, goals (mental)</strong> |</p>
<table>
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<tr>
<td>F, 18,</td>
<td>13/eighth grade onwards, menstruation (paper, calendar); 15-16/tenth and eleventh grade [first smart phone] onwards, health &amp; fitness, heart rate (digital, MapMyRide); 17 onwards [1/2 Iron Man training], health &amp; fitness (paper, notebook) 18 onwards [getting into running, moving away from home], health &amp; fitness, weight, sleep (digital, Garmin Connect), finances (digital, spreadsheet)</td>
</tr>
<tr>
<td>undergraduate student</td>
<td></td>
</tr>
<tr>
<td>P9</td>
<td>19 [undergraduate, started college] onwards, health &amp; fitness, heart rate (digital, Nike+ Run Club); 23 [relocated, bought a condo, graduate school] onwards, finances (digital, Mint), social media followers (digital, Followers), health &amp; fitness, heart rate (digital, Apple iPhone Health); 24 onwards [gifted a Fitbit], health &amp; fitness, heart rate (digital, Fitbit, Achievement), public transportation schedules (digital, spreadsheet)</td>
</tr>
<tr>
<td>M, 25,</td>
<td>11/middle school/early junior high onwards [educational stages], compile knowledge/information &amp; personal notes (paper, commonplace book) 11 onwards [undergraduate, new iPhone], health &amp; fitness (digital, Apple iPhone Health)</td>
</tr>
<tr>
<td>graduate student</td>
<td></td>
</tr>
<tr>
<td>P10</td>
<td>22 onwards [undergraduate, new iPhone], health &amp; fitness (digital, Apple iPhone Health)</td>
</tr>
<tr>
<td>M, 23,</td>
<td>22 [iPhone added Health app, got first car], health &amp; fitness (digital, Apple iPhone Health); 23 [first full-time job after undergrad] onwards, finances (digital, spreadsheet, Mint, Splitwise); 24, habits (paper, digital spreadsheets); 24 [gifted a Fitbit, health problems] onwards, health &amp; fitness, weight (digital, Fitbit)</td>
</tr>
<tr>
<td>undergraduate student</td>
<td></td>
</tr>
<tr>
<td>P11</td>
<td>16, dreams (paper, journal) 18/freshman year of college [lose weight gained in high school] onwards, health &amp; fitness, weight (digital, MyFitnessPal, Apple iPhone Health); 20 onwards, health &amp; fitness (digital, Nike + Run Club); 21 onwards, health &amp; fitness (digital, MapMyRun, Sweatcoin)</td>
</tr>
<tr>
<td>F, 25,</td>
<td>28-32 [birth of child, graduate school], finances (digital, banking app); 29 [got an Apple iPhone], health &amp; fitness, heart rate (digital, MyFitnessPal); 30-31 [relocated], health &amp; fitness, heart rate (digital, Fitbit, MyFitnessPal); 33 [birth of child, gifted Apple Watch] onwards, health &amp; fitness, heart rate (digital, Apple Watch, Apple iPhone Health); 35 [bought a house], home energy use, health &amp; fitness, creative activities (paper, bullet journal)</td>
</tr>
<tr>
<td>graduate student</td>
<td></td>
</tr>
<tr>
<td>P12</td>
<td>28-32 [birth of child, graduate school], finances (digital, banking app); 29 [got an Apple iPhone], health &amp; fitness, heart rate (digital, MyFitnessPal); 30-31 [relocated], health &amp; fitness, heart rate (digital, Fitbit, MyFitnessPal); 33 [birth of child, gifted Apple Watch] onwards, health &amp; fitness, heart rate (digital, Apple Watch, Apple iPhone Health); 35 [bought a house], home energy use, health &amp; fitness, creative activities (paper, bullet journal)</td>
</tr>
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Participants’ survey data was analyzed using descriptive statistics. Interviews were recorded and transcribed, with the resulting 590 pages of qualitative data coded by the primary author using the software program, MAXQDA (VERBI Software GmbH, Berlin, Germany). As part of the data analysis, data from the surveys, interviews, and self-tracking timelines were pulled together to create an overview of participant characteristics and to lay out each participant’s self-tracking practices across time, space, and associated life transitions (see table 2). Coding of the data was carried out using deductive and inductive approaches. Coding took place using a framework outlined by Saldaña: in conjunction with coding for units of social organization (e.g., location/habitat, educational/development/life stages, time-related, social practices, social and personal relationships), initial analysis of the interview data captured
structural codes (codes to capture interview topics), provisional codes (predetermined codes based on prior findings and initial survey data), pattern codes (codes for causes and consequences of actions), and emotions and values coding (i.e., codes for beliefs, attitudes, feelings). The resulting coding frame was hierarchical, with codes organized and analyzed based on their relationship to each other.

The specific codes incorporated into the findings section described below were tied to participants’ experience with and attitude towards self-tracking, including instances where participants noted circumstances that dictated the time they could devote to an activity (self-tracking as contingent and/or discretionary) and when participants talked about self-tracking as it involved data that was missing, anomalous, and disrupted (self-tracking narrativized as lossy). Coding also involved an examination of the units of social organization captured within the participants’ responses as a way to examine what was happening in the data according to these specific dimensions. Several iterative rounds of simultaneous coding were followed by additional rounds of focused coding to create higher-level themes, concepts, and assertions. In the case of the findings laid out below, higher-level themes formed assertions around self-tracking and periodicity and around self-tracking gaps and sense making.

Findings

At an elemental level, we found self-tracking at the micro-level attuned to several forms of periodicity including, as Régnier and Chauvel have noted, significant life transitions. For twelve of the eighteen participants, the connection of self-tracking to the vicissitudes of life manifested in childhood or their teenage years. External interventions, including getting or being gifted a smart phone or a wearable device and having a smart phone that had embedded self-tracking apps, also served as catalysts for what became a self-driven activity. Following adoption, the maintenance or cessation of self-tracking practices was closely tied to a person’s expressed need as they moved in and through various life stages. P2 and P18 exemplify how people drift in and out of self-tracking over extended periods of time, picking up and putting down the activity temporarily or permanently to suit personal or familial needs or wants.
Joining the craze as a pre-adolescent to keep a diary of thoughts and feelings, P2 persisted in this activity until a concern for keeping her diary out of her sister’s hands led her to stop. Sharing an iPhone with her sister in middle school, P2 then tried tracking her menstruation on one of the new period tracker apps. Finding it off-putting after a while, she mainly stopped tracking until a stint in a study abroad program as an undergraduate ignited an interest in tracking her health and fitness. The habit did not stick. Eight months before our interview, she had resumed intermittent self-tracking using a Fitbit gifted to her by her mother two years previously. The impetus came from a decision made in conjunction with her boyfriend to be more intentional about being active and losing weight. Living together had also led them to track shared expenses using a combination of a spreadsheet and the Splitwise app.

Conscious about his weight in middle school, P18 joined a national weight loss program with his mother where he tracked his eating habits and weight loss with a digital app and a paper notebook for meetings. By high school, program costs and a sense that he had control over his weight curtailed his need to track in this area. In his high school years, P18 took up journaling, recording daily thoughts and experiences, a practice that persisted until his first semester in college when he got “way too busy with school.” The effects of stress and anxiety during the first year of college saw a temporary return to tracking weight and food consumption using a digital app. Struggling with time management during his freshman year, P18 later took up bullet journaling—a return to an analog method of planning that allowed him to track his schedule, travel, mood, personal finances, habits, and goals.

The ebb and flow of our participants self-tracking was also revealed at the daily level. Here, university administrator P13 narrated a portion of the rhythm of her day activities as evidenced by the presence and absence and differing intensity levels of her self-tracking data:

You would probably be able to tell what time I woke up in the morning, what time I went to bed based on when I-it starts to track uh, my, the—the number of hours I've been standing. So, you'd be able to see that I wake up about 6 something and then I go to bed about 10 something. Um, that there's a little bit of flurry of activity in the morning where I'm walking around the house getting kids ready, you wouldn't know that that's what I'm doing, but . . . Um, and then there's probably a period of inactivity when I'm checking my
email, and then um, various um, peaks throughout the day depending on whether I'm going to a meeting or people are coming to me.

The demographics of our participants meant that routines and patterns of activity were often of necessity adapted to the rhythms, including the temporal partitions, of the school year. Indeed, the periodicity and tempo of academic life influenced individual socio-temporal rhythms as people sought to bring personal time into alignment with institutional time and campus culture. In the process, self-tracking also influenced the overall goals people were able to set for themselves. During the time of our interviews, graduate student P2, for example, had set a limit on her daily step count because she was devoting more time to academic study. While the sleep goal of undergraduate student P8 was unmet due to the extended waking hours necessary to complete her exams. On the other hand, for graduate student P11, the flexibility of the academic schedule gave her more time to focus on getting back into exercising and optimal health, something she had struggled with when in full time employment.

Even in periods when our participants were actively engaged in self-tracking, activity and data gaps occurred due to unexpected interruptions or breaches to cyclic rhythms. For undergraduate student P8, daily training sessions for a half triathlon followed the cyclical structure and the temporal organization of the running world. Becoming a compunction as she strove to maintain her running streak, she pressed on to day 200 before acquiescing to her mother and her doctor’s advice to give her body a rest. Expected or normative breaks to cyclic rhythms yielded similar results. Karen Stein claims that vacations today are “a primary site at which individuals may take… a pause and suspend connections to the routines and responsibilities that pattern everyday life.” For our participants, the summer and winter breaks enacted continuities and discontinuities in self-tracking practices based on differing social obligations and contrasting rhythms between activity and rest. In some instances, the lack of cues for and dissociation from everyday schedules and routines led to circumstances that negated or subverted self-tracking and associated data collection. Such was the case for P2 who, while on holiday, took a respite from the quotidian demand of tracking grocery expenses. Undergraduate P18 noted a similar effect when talking about tracking using his bullet journal:
This is Christmas, I did not do the weekly tracking thing cause after the semester, I was just like dead. This whole week was a blur because we actually went to Disney World on Christmas day. So I had. . . And my final didn't end until the 19th; didn't get to go home until the 20th. So I had like three days roughly and we had to leave for Houston for a flight early in the morning. So I was like we're doing bare. . . That's what I mean when I say like it changes throughout the week depending on how your life is going. Like that. . . During that time, I just wanted to spend time with family, didn't really think about tracking my moods or habits or anything. It was just bare minimum.

In other instances, the break in routine and/or the change in environment led to behaviors that diverged from the norm and, in some instances, were considered particularly worthy of self-tracking and data collection in that context. For P18, being at Disney World with his family led him to track less with his bullet journal yet he noted that the digital app on his phone automatically recorded his increased step count. P2 was more intentional about tracking her steps while on vacation, believing that part of the fun of being on holiday involved spending quality time with her partner, visiting places together, and striving to beat their step goal in the process:

Holidays are a really interesting one I found, um, so, like going on holiday somewhere, I remember I once had a day where I got to like, 23,000 steps or something, just because we decided that we were going to walk. Um, and that was kind of fun, looking back at that period, because it was really, it was just, I don't know, it was exciting, it was like we were having a really great time. And then we'd like, beat our step goal, and then we'd be like, alright, well, we both beat our step goal, we can't take the tube now, like, [laughs], we may as well just see how long we can keep going for.

As part of these cyclic rhythms, more localized temporal markers played into temporary absences in self-tracking behavior and associated data. Echoing the findings of Behrens and Dinger, we found that gaps were likely to emerge from variable patterns of activity between the weekday and the weekend. Some of these gaps were tied to the way in-home and out-of-home environments were experienced, including differences in spatial and temporal patterns. For
graduate student P9, sedentary weekends at home yielded a lower tally than his daily goal of 10,000 steps. Conversely, the weekday routine of walking to and from the bus stop and navigating the geography of campus made it easier to hit the mark. Gaps were also tied to people having different expectations about what activity patterns should look like on scheduled days versus free days. For academic advisor P3, the weekends were a time to continue to track steps and sleep, with the acknowledgement that she would go easier on herself in the process: “I think the weekends I still track everything... but I’m not as hard on myself because I think I allow my body time to rest. I also don’t do as many like challenges with people on the weekends. So that’s another way that I can kind of like [say], ‘Oh well. I did this many step today. That’s pretty good. It’s a Saturday.’” So, I still am aware of it but not as disciplined.”

For undergraduate student P17, the number of accumulated weekend steps were tied to his social life and whether or not he was out on a date with his partner: “[M]y girlfriend is involved because, if I’m ever going out with her, um, obviously I’m gonna be uh, uh, accumulating steps. Uh, sometimes I’ll go to the movies with her and so, like, I’ll probably have to like go out of my way to actually like go to a movie theater. Like, probably walk around the theater just a little bit. Probably those are the weekends that have more steps to them [laughs].”

The specter of personal and societal obligations was ever present as our participants practiced self-tracking. Those who chose to resist the push for continuous self-surveillance highlighted instances where the will of the individual punctured the goal of the technology and its controlling hand. At times, a consequential tension arose as people sought to navigate their lives and relationships within a framework of social conventions and roles that played out against a backdrop of self-time, interaction time, institutional time, and cyclic time. For student advisor P5, her habit of eating alone at work facilitated food tracking on her digital care app: “I’ve made routines around, uh, tracking my, when I track my food. So, like, if you were to look at my data for lunch, weekdays, it’s, it’s beautiful. It’s, I don’t think there’s ever anything that I’ve missed in the last how many weeks or months.” Yet it was a practice that was consciously disrupted at weekend mealtimes when she chose to devote time to her family rather than interrupt that connection to input data on her smart phone. As P5 stated, “[I]t becomes more important for me to give them that extra 30 seconds that it takes me to track.” This weaving in and out of self-tracking practices was a process of mediation between self-time and family time, between
personal time and social accessibility: “If I have tracked all weekend, it probably was not a great weekend. If I [laughs] [had] not tracked that weekend, it probably was a very family-centered weekend.” For P5, pausing self-tracking to orient time to care for others was a commitment to revalue the non-quantifiable and social aspects of life. The fact that P5 tracked or did not track her activities was a statement of priorities, a decision evaluated in the context of what was most meaningful. If prior research has established that “successful” technology usage can be decoupled from notions of persistence or longevity, P5 makes the case that it should also be decoupled from notions of continuity and abidance.

The case of P5, and others, also amply demonstrates how gaps and anomalies can be activated, brought to life, and accounted for through the narrative process. Echoing Pink et al. our second set of findings focuses on how data (present and absent) becomes meaningful in mundane contexts. The interviews demonstrate that absent data do not always and necessarily create connective gaps between people and their everyday experiences. Indeed, people use data and its absence to make sense of the world around them (at points of time and place and within cultural settings) and to orient themselves and others toward collective concerns. In the process, people are also reconnected and reengaged with their data streams.

As Elsden et al. note, and we corroborate here, one of the ways in which data is meaningful is that it offers a “legible reflection” of life changes. And it is these changes that people bring to life in the narrative process of describing gaps. For several participants (P2, P5, P6, P7, P11), self-tracking gaps were closely tied to personal narratives of states of health and wellness. P7’s account includes a narrative in which she connects self-tracking and its absence to differing responses to situational conditions. Effects of the stress of living in a conflict zone during an undergraduate study abroad program first led her to sleep tracking. The period after her return to the United States was construed through the lens of health progress, with P7 noting a rapid rise in her sleep score according to her data at hand. By the time of our interview, ongoing self-tracking gaps were seen as indicative of an extended period of wellbeing: “So, I'm not using it [sleep tracking app] so much right now because I, um, I have been sleeping pretty well, so I tend to use it when I'm not sleeping well to track it.”

However, for P5, a lack of self-tracking and an associated pause in collecting self-tracking data were tied to a narrative of worsening health conditions manifested at specific points...
in her life: “And for me, I can look back at that and I can tell you around that time what was going on in my life. I can tell you how sick I was. There's, uh, a gap in there that I look and I say, ‘Oh, that was the summer that I had a lot of kidney problems. I had seven surgeries that summer on my kidneys.’” In the process of accounting for and rationalizing these absences, P5’s approach stands in contrast to P7. P5 situated self-tracking gaps not in relation to a typical or expected state of health but in terms of what was atypical or, indeed, troubling: “Another one was when I had had, uh, a heart issue. . . actually, they thought it was a heart issue, and it ended up not being. . . It was a thyroid issue. But, um, it was a change in my health, and so I wanted to reestablish a normal in that area before, as normal as one can be, before I went back to tracking. Um, so, but it's funny because I probably should have tracked through all that.” P2 offered an account in which self-tracking discontinuities or anomalies are seen as indicative of a life diverging both from the norm and the ideal. Instances of low step counts pinpointed periods of illness, times when she was confined to the house or to her bed. Gaps in her self-tracking data were also understood as a reflection of stress, the times when balancing the logistics of student life, work life, and home life took precedent over monitoring her weight, nutrition, and finances. Self-tracking gaps in this instance were tied to a narrative of loss, including a loss of self-care and self-prioritization.

Gaps and anomalies in self-tracking and self-tracking data were also tied to personal narratives centered on socially patterned expectations for leisure and family time and associated cultural models of behavior. An example from the life of P6, a 22-year-old graduate student with family in India, reminds us that stories rely not only on data but on elements that are culturally and personally “pre-figured,” stories that are “populated and furnished with familiar elements.”

Scrolling back to the data from 2015 on his Fitbit app, P6 noted that in July of that year, he was accumulating few daily steps. Accounting for that change in self-tracking activity, his narrative foregrounds the temporal, geographic, and social influences he saw working in concert to discourage his exercise regime: “In July 2015 I had very few steps. So that's, that might be because I'm back home [in Bangalore] and I'm relaxing and my mom is cooking great food and I'm not going out and exercising.” On either side of that experience, he attributed periods of high daily step count to environments and situations conducive to his working out and spending time outdoors, including time spent at work and at school.
If Elsden et al. found that data plays a role in helping to “construct or confirm current or desired identities,” we found that data gaps also formed a part of how people constructed a sense of self, both for themselves and for others. Indeed, we found that revisiting self-tracking data, and the periods of paucity it revealed, brought forth narratives that reinforced but also at times challenged sets of characteristics that people had claimed to categorize and define themselves. In the case of P6 and P7, the data revealed an alternative, perhaps unwelcome, narrative of the self, a narrative that was nevertheless embraced because self-tracking data was seen as offering insights otherwise unavailable to them. In reflecting on deficiencies and intervals in her self-tracking data, P7 noted: “I think that sometimes it feels like what you thought, your impression that you had of yourself was not true. Because, I think for a long time in my life, like I was very active, and then like, um, during college I was not as active, and so I think like, looking at that data, and recording it every day, and seeing like, oh, I don't run five days a week. And I have the proof that I don't do this, and that I'm not that fast. I think that sometimes that is, it's realistic. Like you see a realistic view of yourself, rather than what you wish you saw of yourself. You can't, you can't fool the data I guess.” For P6, data deficiencies and interruptions displayed a truth about how he acted when visiting his family that he would rather have kept from himself and his loved ones: “I thought that when I was home I was not lethargic, I mean not lazy, but there's data to reflect I'm lazy. So, I cannot lie to anybody saying, my mom keeps on saying you should go. I'm like 'okay I'm going to go.' But now she can just tell me 'Look at that' and I'm like caught red-handed.”

On the other hand, gaps or pauses in P5’s self-tracking data corroborated an essential sense of her identity as a loving and attentive partner and a protector of the intimacy of their private life, an understanding she felt compelled to share with her significant other: “Before we lived together, after we had started our dating relationship... I can see patterns where, um, I wasn't data collecting at all on the weekends, uh, because that was our time together. And that's how, and that's one time how I actually showed her that, was I took a screenshot of my history and I sent it to her. And she's like, 'I have no idea what I, what, what you want me to do with this.' (laughing) But I said, 'I want you to see that you're so important to me that I don't even track my stuff when I'm with you.'” For P3, her sense of self was tied to her competitive streak, an identity allied to her data double to the degree that she felt bereft when circumstances...
prevented her from self-tracking during an overseas vacation: “so I recently traveled to South Korea and Japan and um, when I got off the plane in South Korea, my Fitbit broke. And um, I was really upset because I knew that when I was traveling . . . usually when I travel I'll walk like anywhere from 13 to 14 miles a day, cuz I don't wanna spend money on taxis or what not. So I was really upset because I thought, ‘Oh man, like I'm not gonna be able to see how I'm doing and all of my friends back home that I'm in competitions with or that can see my weekly data are just gonna see that I've disappeared.’” For P13, self-tracking allowed her to claim for herself and to proclaim to others an identity that went beyond the roles ascribed to her at work and at home: “this might be weird, but for me, it documents that I'm more than an employee and more than a mom. So, um, I mean, those are my two identities that are like, you know, 90% of my day and my life is about one of those two things. It's about either being an employee and a manager at work or it's about my kids and, you know, how my life bends in different ways to accommodate either work or my—my—my kids and my husband, to some extent, too. Um, and I think, for me, the time that I spend working out, the time is sort of me time.” The disruption of this projection of the self that was engendered by a breach in her self-tracking data is richly described in her narrative: “my—my son broke his um, femur, um, about 3 weeks ago, and I was in the hospital with him overnight, and I didn't ha—and it was unexpectedly, of course, unexpectedly that he broke his femur. So, um, I didn't have any of my um, charging ports, so my watch went dead and I put it in my uh purse, and I'd forgotten where I put it and um, so I—I, for the last 3 weeks, I haven't worn it. Um, and then I discovered it yesterday when I was going through my purse and I was so excited that I found it. But every time I would go to work out in the last 3 weeks, um, I would have this thought of like, ‘Ugh, this doesn't even, I don't get credit for this. No one's gonna know. I'm the only person who knows.’”

Discussion

Self-tracking and the Concept of Social Time

In line with Pink et al.’s concepts of “mundane” and “broken” data, our findings bring to life the ebb and flow in the generation and accumulation of personal self-tracking data.125 If Pink
et al.’s work focuses on data gaps as the result of digital material breakages combined with idiosyncratic self-tracking practices, our findings highlight an additional and distinctive temporal dimension to micro-level gaps in self-tracking. While Epstein et al. note variations in schedule and routine as external forces that lead to self-tracking gaps, our work deepens the understanding of how socio-temporal rhythms and the temporal organization of life impact self-tracking in ways that allow for absences, spaces, discontinuities, pauses and breaches in human activity and in the associated data that emerges from the self-tracking process. Paraphrasing Flaherty and Seipp-Williams, we find that self-tracking offers up “a constant tide of measurable units that seems to ebb and flow in response to the pull of social forces.” In such a frame, self-tracking and its absence are found to be co-existent and mutually dependent practices.

The notion that there are socio-temporal rhythms to life is long established in the sociological literature, with Émile Durkheim’s work on the sociology of time noted in this regard. Drawing on Durkheim’s understanding of time as a social fact, sociologists Pitirim Sorokin and Robert Merton introduced the concept of social time. Social time is the humanized concept of temporality in which people attune themselves not only to physical and natural realities or points of reference but also to social ones. As Sorokin and Merton state: “[S]ocial time, in contrast to the time of astronomy, is qualitative and not purely quantitative. . . . these qualities derive from the beliefs and customs common to the group. . . . and reveal the rhythms, pulsations, and beats of the societies in which they are found.” If physical time “inexorably marches on in relatively homogenous units,” social time “unfolds with various rhythms; sometimes rapidly, sometimes slowly, and sometimes with breaks (e.g. sleep or holidays).”

Lewis and Weigert delineated the forms of social time that operate within and that overlay different structural levels in society: “at the individual, ‘self-time’; at the group level, ‘interaction time’ for informal interactions and ‘institutional time’ for bureaucracies and other formal organizations; and at the broad, societal-cultural level, ‘cyclic time’ (the day, week, and seasons) which cut across the entire society.” This framework is attuned to how time is socially determined in sequence and in demarcation, including in reference to events and periodicities (e.g., “the daily round of activities,” the “weekly routine,” and “the yearly seasons”).
and to alternations or distinctions between temporal markers (e.g., between weekdays and weekends and work time and private time).\textsuperscript{133}

Taken as a whole, our data suggest that continuity of self-tracking is most likely when tied to activities that are predictable and routine, thus helping to ingratiate the practice into the rhythms and patterns of daily life. Connections to self-tracking are also more likely to persist in conditions where patterns and insights are sustained, contingent on the accrual of data. That said, a recurrent theme in participant interviews is that variabilities and allocations of social time (social time as it exists within different structural levels and within different temporal sequences and markers) impact participants’ lives in ways that allow for expected and unexpected gaps to occur in self-tracking activities and in the resultant data. Certainly, the findings point to the importance of the concept of \textit{social time} for understanding a natural source of continuity and discontinuity to self-tracking. It is social time that forms the broader social framework in which self-tracking “lapses” and “streaks” can be understood.\textsuperscript{134}

\textit{Self-tracking and the Concept of Narrativity}

In addition to uncovering the social rhythms and patterns of daily existence that result in gaps and anomalies in self-tracking data, our findings establish the ways in which people make sense of the resulting absences and incongruities that reside in the resultant self-tracking data. Pink et al.’s work demonstrates how people physically infill and repair their self-tracking data to make meaning from it.\textsuperscript{135} Leaving the material reality of the data aside, our findings emphasize the work of infilling and repair that happens at the narrative level. In line with the findings of Dourish and Gómez Cruz, narrative acts are shown to take place “around the data, with the data, before and after data, in line with or in contradiction to data, and more.”\textsuperscript{136}

Although not the first to note that people are capable of assigning meaning to data gaps,\textsuperscript{137} our findings address the call in the HCI literature to further study how people perceive and interpret these gaps, including how they are explained or compensated for.\textsuperscript{138} The specific contribution of our work is in the introduction of the concept of \textit{accountable} and \textit{expressive} gaps (see table 1), foregrounding the work that people do as part of self-tracking to make sense of data privations, discontinuities, and rifts. In developing this concept, we attune our work to that of
sociologist Harold Garfinkel whose ethnomethodological program provides a basis for examining how humans create and make meaning from the social world around them.\textsuperscript{139} From the perspective of ethnomethodology, everyday life is seen as an accomplishment, something that people create through the use of methods including that of \textit{accounting}.\textsuperscript{140} A method of operating in life, accounting refers to the way in which members “make their everyday activities “visible,” “rational,” and “reportable” (i.e., accountable) to themselves and to others.\textsuperscript{141} It is an acknowledgment that people use the medium of description to make life intelligible. As Trace notes, “having knowledge of their own situation, members can account for their own actions.”\textsuperscript{142} In this scenario, self-tracking data (in its completeness and incompleteness) is seen as indexical—as an object that has meaning in context.

Thus, the notion of \textit{accountable} speaks to people’s ability to construct and produce their understanding of the everyday world, including isolating, contextualizing, describing, and explaining the gaps that, as we have established, are a normal part of self-tracking. At a fundamental level, gaps serve as signposts or shortcuts, allowing “unintended traces/inferences” to be brought to life.\textsuperscript{143} The notion of \textit{expressive} gaps speaks to the role narrativity and storytelling play in people’s creating and conveying such understandings. A vignette from our interview with student advisor P5 highlights these concepts in play: “\textit{You can see gaps. And, uh, I guess based on whatever you’re tracking, you can kind of look and, and remember what pops out about that. Like here, like I can tell you on my timeline that I know that this is a thing and the reason why I didn’t, um, track so much in my journal was because my dad was sick. So, I think you can see a lot. Um, not always directly representative of what, why you’re not tracking, but things going on in people’s lives.”

Indeed, we found that narration was fundamental to the ways in which people “managed, oriented towards, and understood the data generated by the system in relation to their own experience” and that of others.\textsuperscript{144} As Dourish and Gómez Cruz note, “in seeing or framing data as a trace of an event or an action, we inherently invoke narrative elements: actors, motives, expectations, actions, types, histories, proclivities, habits, intents, and on.”\textsuperscript{145} Dourish and Gómez Cruz call this “the enlivening of data and data sets as they are mobilized in and through narrative.”\textsuperscript{146} As the authors note, “data do not speak for themselves. Data must be narrated—put to work in particular contexts, sunk into narratives that give them shape and meaning, and
mobilized as part of broader processes of interpretation and meaning-making." For our participants, narrative elements were usually organized on a temporal basis with data gaps described and explained in relation to patterns and experiences of daily life. These are stories of transition (e.g., being in college), of joy (e.g., spending time with loved ones), of upheaval (e.g., personal and family illness), and of shifting roles and priorities (e.g., when family takes precedence over the needs and wants of the individual). Narratives or stories built from absent data frame life’s everyday moments and challenges, reveal new discernments, reinforce assumptions and expectations, and center and decenter understandings of the self.

Echoing the ethnomethodological sensibility, the notion of “data-work” as a method of sense-making is ever present in these stories. For Elsden et al., data-work is the situated work that people do to translate, contextualize, and make sense of their data and the language they use in the process. Data-work is also said to involve peoples’ work of “relating recognizable features of the data to remembered experience, routines and known facts about one’s life.” Our findings emphasize the use of accounting as a form of data-work centered on repair, a process that takes place through micro-routines of reminiscing. In many of the instances of self-tracking described here, the consultation is not foremost in one’s own memory. It is the tracking or storage device, and what it foregrounds, that often leads one to recall an event. Returning to the notion of algorithmic visuality, people engage with data as it is archived by the application. While ongoing data accumulation provides a vital feedback loop to the app company, an accumulation of this transactional data is also encountered by the subject when scrolling through the back-end archive.

Bergroth argues that the way self-tracking data works to establish “factualities” about the past, present, and future self is through “relations to similar data in different spatial or temporal locations.” Specifically, the self is “made known through assembly work” with every data point requiring a “connection to other data points to become a medium of self-related knowledge.” These data relations allow self-tracking to be understood as a linear practice, an embodiment of the progress of the self as extended through space and time. Accounting is an example of how people are “active” with self-tracking. Acts of accounting promote and reflect patterns of behavior that help connect people to their own sense of their unfolding self. Moreover, our findings suggest that factualities about the self are established through connection
to data points that are both present and absent, expected and unexpected. We view data gaps as an integral part of a larger ecosystem that includes daily data averages and data anomalies (data “spikes”) that presage an increase or a decrease in self-tracking. It is our claim that the element of contrast is one of the methods people use to make each state especially meaningful. Mentions and silences, as Trouillot states, are “active, dialectic counterparts.”

Conclusion

Self-tracking forms a portrait of the material culture, behavior, and activities of people at set moments in and across time, housed within broader societal structures, practices, and controls. This article investigated the “gaps” and “absences” that accompany self-tracking, populating a typology of gaps that cascade from macro- to meso- to micro-level contexts. In the process, their associated reach, frequency, duration, and impact have been described.

At the macro level, gaps in the activities documented via self-tracking are external and systemic, existing as deficiencies at a structural level. At the meso level, gaps are absences or disparities that exist at the community and organizational level, whether indicative of constraints imposed by people’s environment or lack of control over information as it crosses personal boundaries to form part of larger public or private systems of recordkeeping. Embedded within what Dourish and Gómez Cruz call “regimes of measurement and management,” gaps at the societal and group level indicate that the activities, technologies, and data traces of self-tracking are unequally situated in the world. Gaps at the macro level reveal that self-tracking, and the adoption of digital devices to manage this activity, is incomplete as a universal pursuit. Gaps at the meso level reveal that when self-tracking does exist, it is often accompanied by a data distribution problem. Attempts to bridge activity and data gaps at the macro and meso levels require large-scale, complex, and disparate interventions from broadening global public health surveillance, improving national healthcare systems, and implementing policies to reduce socio-economic disparities, to supporting human-centered approaches to the collection and dissemination of big data. In the latter case, this effort includes acknowledging that the interests of some communities and individuals are not served by their data being collected, infilled, or reused. In these cases, the absence of data is a perceptive, reasonable, and ethical choice.
Micro-level gaps follow the lapses and streaks that typify patterns of self-tracking at the individual level as people navigate social settings and contexts. Our sometimes fragile (ties to) technology, behavioral and personality traits, and the general vagaries of day-to-day life, work to interrupt people’s self-tracking activities, as well as their connection to its associated devices and data. In this context, absences, deficits, deficiencies, intervals, pauses, discontinuities, and breaches in self-tracking data usually have a negative connotation. A primary concern is that such gaps lead people to disassociate from their data and the technology and practices that brings it into being. This article calls attention to and develops the concept of the accountable and expressive gap as an analytical entry point for understanding how people make meaning and find value in the gaps and anomalies that litter their self-tracking data. Paraphrasing Elsden, Kirk, and Durant, making meaning from extant, anomalous, and absent self-tracking data involves noticing and reflecting on life transitions and changes, reminiscing on movements and periods of life, and having a sense of attachment to data as a personal collection and as a representation of the self.154

From a critical data studies perspective, our findings support the study of forms and sources of data and the reasons for and consequences of its absence across and among all societal levels. Our findings show that there is a particular opportunity to study how connections can result from data in a state of presence and of absence—that is, to study how the work of narrativization and infilling happens around data whether it is ostensibly lossless or lossy. From a human-computer interaction perspective, our findings suggest that in the self-tracking sphere, design interventions should occur with the documentary potential of data gaps in mind; such research should recognize micro-level gaps as part of the natural order and indeed the very essence of the self-tracking process. Designing for accountable and expressive gaps means embracing the idea that gaps not only exist in self-tracking but can be made meaningful. To do so means augmenting their existence, giving people the tools to demarcate, describe, and reflect on data spikes and data gaps as reflections of a life well lived.155 Finally, from an archival perspective, our findings support the idea that self-tracking data should be situated as a new form of historical source, one that, as assembled in and over time, provides rich granular evidence of peoples’ behaviors, activities, and sense of self. In moving self-tracking data from the private and corporate sphere to the public realm, archival science can build from our findings to value, plan, and account for the temporality, partialness, and narrativity of self-tracking data. In already
published findings, we have imagined what a quantified-self archive would entail, so we finish this article by inviting interested parties to engage with our work to help bring it to fruition.\textsuperscript{156}

Notes

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\textsuperscript{4} Kelly, \textit{The Inevitable}; Kitchin and Lauriault, “Data and Data Infrastructures.”


10 Hallal, et al., “Global Physical Activity Levels.”


18 Growth from Knowledge (Gfk), “Health and Fitness Tracking.”


23 Schüll, 319.

24 Schüll, 325.


32 Pink and Fors, “Being in a Mediated World,” 375–388.


34 Kitchin and Lauriault, “Data and Data Infrastructures,” 83.


43 Pink, et al., “Broken Data.”


Dalton, Taylor, and Thatcher, “Critical Data Studies: A Dialog on Data and Space.”
Sarah Pink, Minna Ruckenstein, Robert Willim, Elisenda Ardèvol, Martin Berg, Melisa Duque, Vaike Fors, Debora Lanzeni, Francesco Lapenta, and Deborah Lupton, Data Ethnographies 5: Broken Data (Data Ethnographies) (Digital Ethnography Research Centre (DERC), 2016).
Pink, et al., Data Ethnographies 5.
Dourish and Gómez Cruz, “Datafication and Data Fiction,” 1.
Rettberg, Seeing Ourselves Through Technology.
Dourish and Gómez Cruz, “Datafication and Data Fiction,” 1.
Pink and Fors, “Self-tracking and Mobile Media.”
Dourish and Gómez Cruz, “Datafication and Data Fiction,” 5.
Dourish and Gómez Cruz, “Datafication and Data Fiction,” 7.
Ayobi, Marshall, and Cox, “Reflections on 5 Years of Personal Informatics,” 2777.

Crawford, Lingel, and Karppi, 486.

Ayobi, Marshall, and Cox, 2775.


72 Yli-Kauhaluoma and Pantzar, “Seeking Connectivity to Everyday Health and Wellness Experiences.”


77 Jarrahi, Gafinowitz, and Shin, 444.

78 Ayobi, Marshall, and Cox, “Reflections on 5 Years of Personal Informatics,” 2777.

79 Ayobi, Marshall, and Cox, 2776.


83 Clawson, et al., “No Longer Wearing.”


87 Rooksby, et al., “Personal Tracking as Lived Informatics,” 1171.


91 Elsden and Kirk, “A Quantified Past: Remembering with Personal Informatics.”


104 Carter, 227.

105 Trace and Zhang, “The Quantified-Self Archive,” 296.


Hobbs, 127. In contrast, shifting the focus from authorial purpose to reader response, Douglas and Mills argue that what determines whether a record is personal in nature is not inherent to the artifact, its creation and organization, or the activity in which it engages. If Hobbs reveals personal records as places where human life is constructed and enacted, Douglas and Mills equate the personal to the ways in which records are subsequently experienced and activated, in how they are put to use. Douglas and Mills, “From the Sidelines to the Center.”


Acker, “When Is a Record?” 298.


The findings from our study of the long-term value of quantified self data can be found in Trace and Zhang, “Configuring Personal Data for a Quantified-Self Archive,” and Trace and Zhang, “The Quantified-Self Archive.”

Trace and Zhang, “The Quantified-Self Archive.”


121 Pink, et al., “Mundane Data.”


123 Dourish, and Gómez Cruz, “Datafication and Data Fiction,” 7.


132 Lewis and Weigert, 434.

133 Lewis and Weigert; Flaherty and Seipp-Williams, “Sociotemporal Rhythms in E-mail,” 39–49.


135 Pink, et al., “Broken Data.”


144 Dourish, and Gómez Cruz, “Datafication and Data Fiction,” 2.

145 Dourish, and Gómez Cruz, 4.

146 Dourish, and Gómez Cruz, 5.

147 Dourish, and Gómez Cruz, 1.


150 Bergroth, “‘You Can’t Really Control Life,’” 191, 193.

151 Bergroth, 190-206.

152 Trouillot, Silencing the Past, 48.

153 Dourish, and Gómez Cruz, “Datafication and Data Fiction,” 7.
154 Elsdon, Kirk, and Durrant, “A Quantified Past: Toward Design for Remembering with Personal Informatics.”

155 For further information on the design implications of self-tracking gaps, see Ciaran B. Trace and Yan Zhang, “Towards a Typology of Self-tracking Gaps.”

156 See Trace and Zhang, “The Quantified-Self Archive.”