Chapter 5
Seniors and Self-tracking Technology

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5.1 Introduction

While older adults use self-tracking for health more than any other age group in the U.S., they seldom use self-tracking technology (Fox and Duggan 2013). Self-tracking can be used for many purposes, including monitoring health indicators, learning about how one responds to different scenarios, and supporting behavior change. Each of these actions can be part of seniors' health management activities, and technology has the potential to facilitate and augment this practice (e.g., by reducing the effort required or assisting users to interpret their data). While the majority of self-tracking industry and research focuses on the younger population, seniors have particular needs. In comparison to younger age groups, they have a higher prevalence of chronic illness (Ward et al. 2014), track different health indicators, and use different tools to track health information (Fox and Duggan 2013). In order for seniors to benefit from the tools provided by self-tracking technology, it is necessary to design systems more aligned with their needs and practices.

Self-tracking refers to repeatedly measuring and recording information about oneself. In the case of self-tracking for health, such information may include activities such as medication intake and health indicators such as blood pressure. Terms such as self-monitoring, Personal Informatics, and Quantified Self can refer to similar practices. We utilize self-tracking as an umbrella term.

In this chapter, we provide a review of seniors' use of self-tracking and self-tracking technology. We describe relevant findings and highlight opportunities for future research. Our goals are to introduce the reader to this area of research,

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discuss seniors' known tracking practices, and the existing challenges to the design, adoption, and use of self-tracking technology for seniors. Although self-tracking techniques can be used for a range of purposes, including financial transactions or time spent commuting, we focus on health because to the best of our knowledge, most research involving self-tracking and seniors has focused on health applications. However, we highlight that given differences in seniors' perspectives, goals, and situations in different aspects of life (e.g., finances, retirement), it is likely that they will have different needs in other kinds of self-tracking as well. We do not include the perspectives of caregivers or assistive technology for seniors as they are outside of the scope of this chapter.

5.2 Self-tracking

The practice of registering information about oneself has existed as long as the written language (Rettberg 2014). Self-tracking consists of repeatedly measuring and recording information about oneself. The data collected might involve behavior (e.g., sleep), physiological measurements (e.g., heart rate), and contextual information (e.g., calendar appointments, weather). These data might be quantitative or qualitative (Li et al. 2011).

There are five main reasons behind tracking. First, self-knowledge can include learning about habits (e.g., how often one eats fruit), or learning about how an illness manifests (e.g., when symptoms occur). Second, behavior change is based on changing a habit, either by acquiring or eliminating it. Third, self-experimentation is based on evaluating the effects of a particular behavior or circumstance by self-tracking both when it is present and when it is not. Fourth, assessment involves temporarily observing a behavior or other measurement (e.g., measuring blood pressure daily for a week to estimate its average). Fifth, monitoring refers to continuously measuring a variable to observe short term or long-term patterns (e.g., how a behavior changes over the course of a week or a year) (Intille 2004; Li et al. 2011; Choe et al. 2014; Karkar et al. 2015; Caldeira et al. 2016).

Given the diverse possibilities in methods and reasons for tracking, this practice can take place very differently for different populations. Most current self-tracking technologies leverage mobile Internet connected devices. We consider self-tracking technology any digital system (both apps and devices) that help users collect or store their data. They include illness specific devices such as glucose meters and general-purpose systems such as activity trackers. Activity trackers are among the main self-tracking tools currently available, and the majority of papers included in this review focus on this kind of system. Their functionalities, assumptions, visual design, and advertising are focused on young and middle-aged adults. This focus is partially due to the relationship of self-tracking system industry with the Quantified Self community, which was created in the Silicon Valley and attracts a majority of technology enthusiasts (Choe et al. 2014). Assumptions held by these systems (e.g., more exercise is always better) may not hold for many seniors who have cardiovas-

cular diseases, physical limitations due to disability or illnesses such as chronic pain, osteoporosis, and arthritis. These differences in needs and purposes behind tracking are particularly visible in the case of health, as the health of seniors differs from younger populations.

5.3 Method

This chapter provides an overview of research (Grant and Booth 2009) of literature investigating self-tracking among older adults. It covers more than 50 papers published between 2007 and 2017 in the fields of HCI and Medical Informatics. These papers were obtained through searches using keywords relevant to each topic (e.g., seniors, elderly, quantified self) in multiple search engines (e.g., ACM Digital Library, hcibib.org, Google Scholar). Additional papers were found iteratively by scanning each paper's references. Each paper included in this review met three criteria: written in English, focuses on self-tracking, and focuses primarily on seniors or provides specific data about this population (e.g. Fox and Duggan 2013). These papers were analyzed thematically. They provide insights into seniors' current use of self-tracking, their opinions and perspectives about self-tracking technology, and existing barriers to adoption and use. These findings are discussed in the following sections.

5.4 Seniors' Use of Self-tracking

Seniors' self-tracking practices and goals differ from other age groups. Unlike the younger age groups who primarily track to pursue fitness goals, seniors are more likely to track health indicators not related to fitness, such as blood pressure and blood glucose. In comparison with younger adults, they are also much less likely to use technologies such as mobile phones and computers to track, and more likely to use paper (Fox and Duggan 2013). They often use just memory rather than recording data, due to the effort required, disruption of routine, difficulty using tools, avoiding thinking about illness, and fearing to lose the data (Miller et al. 2013). Older adults' current use of technologies for tracking exercise focuses on monitoring and assessment rather than behavior change, as they do not believe it to be helpful as a motivation tool for increasing exercise habits (Caldeira et al. 2016, 2017). This issue explains the low adoption of tracking technology by seniors, and it is influenced by how they are designed for younger users' needs.

Studies investigating seniors' interests and use of specific tools have found promising results. Seniors have expressed interest in tracking several kinds of information (e.g., rest, social interactions, symptoms, and weight) (Davidson and Jensen 2013). Many studies have focused on tracking for the management of chronic illness among seniors, such as diabetes (Arnhold et al. 2014; Lo et al. 2014;

Whitlock et al. 2015), heart health (Karshmer and Karshmer 2004; Lorenz et al. 2007; Mohan et al. 2008), pain management (McCann et al. 2009; Barg-Walkow et al. 2013, 2014; Tsai et al. 2015), medication tracking (Sailer et al. 2015), and fall detection (Gonzalez et al. 2014).

Research on the use of technology for tracking exercise has led to mixed results for the older adult population. Step counting has shown a significant impact, such as 23–83% increase in step count after 6 months, and improvements in fear of falling, locomotive function, leg strength, walking speed, blood pressure, and weight (Snyder et al. 2011; Yamada et al. 2012; Ashe et al. 2015). In a study with participants over 50 years old using activity trackers, 45% reported increased motivation for healthier habits, and 46% reported increased activity, improved sleep or eating habits. Participants enjoyed learning about their exercise and sleep habits and confirming activity levels (AARP 2015; Burton 2016). Several other studies have also found positive results and experiences (Rasche et al. 2015; McMahon et al. 2016; Phillips et al. 2016; Schlomann et al. 2016). However, multiple studies found no significant increases in activity levels when incorporating a Fitbit into an existing intervention (McMurdo et al. 2010; Thompson et al. 2014). Strategies used to promote or facilitate physical activity have included personalized goal setting, problem solving, social comparisons and support (King et al. 2013), haptic feedback (Qian et al. 2010), wearable camera, activity tracker (Harvey et al. 2016), and video (Bagalkot and Sokoler 2011).

5.5 Barriers to Self-tracking Technology Adoption

Several factors limit seniors' adoption of self-tracking technology: mismatch between their needs with those of younger users, poor design for older adults, low perceived usefulness, ineffective motivation strategies, chronic illness related challenges, and attitude towards self-tracking technology. Table 5.1 shows a summary of these barriers, along with examples.

Due to the focus on younger users, existing technology does not meet many of seniors' needs. Older adults have shown more interest in tracking steps and heart rate, while younger users are more interested in sleep and distance (Rasche et al. 2016; Schlomann et al. 2016). Although the reason for the difference in preferences is unknown, it is likely that it is influenced by different goals, as seniors are more likely to use tracking as a tool in illness management, and younger users are more interested in prevention and fitness (Fox and Duggan 2013). Goals such as 10,000 daily steps can also cause overexertion in older adults (Schlomann et al. 2016).

Poor design for seniors is another issue that hinders the use of self-tracking technology. Issues such as inaccuracy, perceived inaccuracy, unclear instructions, and discomfort (AARP 2015; Burton 2016), difficulties setting up a device and interpreting data (Mercer et al. 2016), and insufficient error prevention (Preusse et al. 2017) discourage continued use of wearable activity trackers. Lack of accuracy can be a substantial problem for seniors as they value it more than other populations

(Rasche et al. 2016). Validation studies have found that activity trackers underestimated steps of free walking participants (i.e., those who did not use walk aids) by up to 27%, and accuracy was worse among those who used walkers (Floegel et al. 2016). For seniors who walk slowly or use walking aids, ankle worn devices tend to be more accurate (Simpson et al. 2015; Floegel et al. 2016; Klassen et al. 2016). Failing to detect steps when exercising differently than expected by the device, such as holding a treadmill bar, can also cause frustration in users (Fausset et al. 2013).

Perceived usefulness of exercise tracking devices is low, particularly among seniors who are already physically active (Fan et al. 2012). In general, seniors have been found to use these tools for monitoring purposes but not as a behavior change tool. This perception is attributed to seniors already knowing their habits and having little variation in routine, and finding technology less motivating than the benefits of exercise (e.g., reduced pain) (Caldeira et al. 2017).

Since seniors are more likely to use tracking as a tool for managing chronic conditions, they also experience more challenges caused by or related to these diseases. Seniors who use self-tracking to manage chronic conditions can experience an augmented awareness of the disease and its ill effects. Self-tracking symptoms or indicators related to a disease (e.g., blood pressure) can become a reminder of the users' health issues (Karshmer and Karshmer 2004). Anker et al. have described this

Table 5.1 Existing barriers for the use of self-tracking technology among seniors

Mismatch in tracking needs with younger age groups
Interested in tracking different data (e.g., heart rate, steps)
A higher focus on chronic illness management
Goals can be too ambitious for seniors (e.g., 10,000 steps/day)
Poor design for older adults
Lower accuracy of step tracking among seniors who walk slowly, use walking aids, or hold the handle on a treadmill
Wearable device bothers seniors' skin
Difficulties with setting up the device, syncing data, interpreting data
Low perceived usefulness
Less motivating than other benefits (e.g., reduced pain)
Already knowing habits, low variation in routine
Not provide enough benefits in comparison with paper (monitoring)
Inadequate motivation strategies
Theory-based strategies have a lower effect (e.g., goal setting)
Pre-existing motivation affects response to different strategies
Negative impact on Self-efficacy or Locus of control
Challenges related to chronic illness
Coping with illnesses
Reinforcing stigmatized aspects of aging
Increased awareness of illness
Attitude towards self-tracking technology
Distrusting system, preferring health provider
Quick abandonment
Increased rejection of tracking technology with age

experience as unpleasant, evoking intense negative emotions (Ancker et al. 2015). The stigma associated with old age, illness, and disability can cause resistance to the adoption of technology for health and assistance. Due to stigma, many seniors prefer mainstream tools (Light et al. 2015) and reject devices that have a medical aesthetic or are designed specifically for older adults (Durick et al. 2013). Even seniors in poor health conditions can often perceive other older adults as having worse health (White et al. 2012).

Further, an essential aspect of self-management for older adults is coping with an illness, and the changes it requires. Coping influences seniors' attitudes, which in turn affects the experience and outcomes of using health technology. Tools that highlight issues that have a negative impact on users' psychological well-being may hinder the process of coping with illness.

Theory-based strategies for behavior change (e.g., Transtheoretical Model of Behavior Change, Goal Setting Theory) are used often in self-tracking research and system design, as they increase the impact of interventions (Orji and Moffatt 2018). However, several strategies based on these theories (e.g., goal setting, prompting data collection) are significantly less effective for older adults in comparison with other age groups (French et al. 2014). Seniors are also often more interested in seeing mistakes than regular 'correct' behavior in the tracked data (Lee and Dey 2011). This tendency, along with an increased awareness of one's illness, may influence how they see themselves and their conditions. As a consequence, internal processes such as self-efficacy and health locus of control, which are linked to health management behavior and health outcomes (Cross et al. 2005), could be negatively impacted.

Lastly, different aspects of seniors' attitudes towards self-tracking technology limit their adoption and use. This population can distrust measurements and prefer to interact with a clinician (Karshmer and Karshmer 2004). In a project that investigated an intervention using activity trackers to promote physical activity, only participants who wanted to be active but needed more motivation found it beneficial. Active participants did not see it as useful as a motivational tool, and unmotivated seniors were more interested in playful approaches (Fan et al. 2012). Deployment studies also found that participants' attitudes towards these devices becomes increasingly negative over time, with most participants abandoning after two weeks (Fausset et al. 2013). Older seniors tend to use the devices less consistently, abandon earlier (AARP 2015; Burton 2016) and are more likely to perceive it as a 'gimmick' (Schlomann et al. 2016).

The barriers limiting the use of self-tracking technology are similar to barriers found for other kinds of systems among senior users: low perceived ease of use and usefulness (Conci et al. 2009), frustration, physical and mental limitations, and mistrust (Gatto and Tak 2008). However, the specific instances where these barriers have been identified reveal that seniors have very particular needs that are not addressed by existing technologies.

5.6 Overcoming Barriers

The barriers present for the adoption of self-tracking technology by seniors are plentiful and several factors need to be addressed. Primarily, both academia and industry must increase the involvement of seniors in the design of self-tracking devices. Increasing awareness of the benefits of activity trackers for this population is also essential to promote adoption (Fausset et al. 2013). Further, the design of self-tracking tools must become more adaptable to diverse needs, contexts, and abilities.

Seniors' attitudes and perceptions are key to increasing adoption. It is important for more projects to propose and test solutions to these issues through user-centered and participatory design approaches with seniors (Mitzner and Dijkstra 2017). Future research should investigate attitudes toward exercise, behavior change, and adoption of technology to inform the design of devices and interventions (Araullo and Potter 2016). Activity trackers should aim to meet seniors' goals, become more straightforward to set up, comfortable and unobtrusive to wear and become more engaging. Detailed and easy instructions, transparency about data collection, robustness, comfort, and targeting specific conditions are also required (AARP 2015; Burton 2016). Specific appropriate guidelines (e.g., ideal step count for seniors) could also help with interpreting data and setting goals (Schlomann et al. 2016). Making mainstream technology more friendly to seniors could help to reduce the barriers caused by stigma, and lead to cost-effective tools (Helal et al. 2008; Durick et al. 2013).

It is likely that cohort effects influence some of these barriers. Current challenges in design and adoption of technology for seniors are expected to be partially mitigated with time as technology improves, its use to assist seniors becomes more common, and individuals who are familiar with technology age into late life (Yusif et al. 2016). Because individuals' attitudes and preferences are affected by past life experiences (DeFriese and Ory 1998), it can be difficult to understand what findings are due to aging, and which are generational (Dean et al. 1986). However, it is likely that many aspects of existing barriers are not generation specific, as seniors' health and context are most likely partially responsible for several known barriers—including issues regarding accuracy, and the perceived usefulness of devices. Data on multiple cohorts are necessary to understand the effects of new technology on seniors (Casilari and Oviedo-Jiménez 2015). Still, working towards addressing the current known barriers is likely to benefit future generations of older adults.

5.7 Research Gaps and Future Directions

Beyond addressing barriers, there are opportunities for further research in other aspects of older adults' use of self-tracking technologies. Future studies investigating self-experiments, different kinds of tracking, and focusing on underrepresented populations could lead to valuable contributions.

Because assumptions and myths that underestimate seniors' health and abilities are common, research often focuses on seniors' deficits, illnesses, disabilities (Durick et al. 2013) and alienate the seniors who do not fit in those assumptions. Community-dwelling seniors do not necessarily share the same needs as the younger population, as their context is different (Durick et al. 2013). Thus, focusing on this population of capable but different senior users is important.

Self-experimenting can be a powerful application of self-tracking (Karkar et al. 2015), but little research has investigated this direction with seniors. This kind of tracking is particularly interesting for this population because seniors are very diverse, often needing to manage different conditions, past medical issues, and special needs. Seniors have the potential to benefit from self-experimentation, such as having more agency in their care and being able to make better-informed decisions about their health.

There is also much that can be pursued in regards to tracking that is not related to health care (e.g., Durrant et al. 2017). Better understanding this population's interests, perspectives, and usage of different kinds of tracking could inform the design of useful tools for them, while at the same time generating valuable in-sights for health-focused tracking.

A better representation of seniors' in their diverse contexts is necessary to design technologies that meet their needs. While a few of the cited works include a large representative sample of seniors (e.g., Fox and Duggan 2013, most studies in this area have focused on small samples with low diversity. Seniors with different health contexts, ages, and professional background might have different perspectives towards self-tracking and self-tracking technology (Dugas et al. 2018).

Further, many studies exclude or under represent seniors in their participants or subjects. This issue is aggravated by the evidence of stigma and rejection of tools meant for older adults. Increasing the inclusion of this population in regular studies could provide more insights about the perspectives of independent older adults, and promote design that considers their needs (Davidson and Jensen 2013), even for systems that are not designed particularly for this population. While systems have been designed specifically for seniors (Tedesco et al. 2017), many of them might prefer to use technology designed for the general population.

Lastly, many technologies for senior health target older adults with special needs or their caregivers. However, the aging process is gradual, and there is potential for leveraging both self-tracking and monitoring to offer adequate support for seniors who are at risk for cognitive decline but are still independent. Because self-tracking is more empowering in comparison with monitoring by a third party, it could help fulfill some of the functions of monitoring while lowering issues caused by stigma or power imbalance. This approach can be implemented by sharing tracked data with seniors' adult children (Binda et al. 2017).

5.8 Pursuing Actionable Insights

Most of the research investigating seniors' use of self-tracking has been published in the Medical Informatics field, and their reported findings are often not granular enough to inform technology design. Medical informatics articles often investigate tools that are similar to the work found in the HCI literature. However, they tend to focus on medically relevant outcomes, such as changes in activity levels and hospital admission rates, rather than on the system itself (e.g., Snyder et al. 2011; Yamada et al. 2012; Ashe et al. 2015). These studies tend to evaluate complex intervention programs that include elements such as educational materials, communication with clinicians, and multi-component systems (e.g., McMurdo et al. 2010; Thompson et al. 2014). This literature seeks to validate interventions' effectiveness, prioritizing this measure over understanding the elements that influence effectiveness, such as system design and user experience.

These projects help us to understand the impact that technological tools have on measurable health indicators (e.g., strength, physical fitness), and healthcare outcomes (e.g., costs of care over a period, rates of hospital readmission). They provide evidence of the health benefits of many health technologies, an essential aspect of evaluating these systems that the HCI field does not address. Evidence about the benefits of health technology supports future studies in HCI. However, these methods cannot provide insights into what kinds of elements of intervention influenced the results.

As argued by Klasnja et al. (2017), moving the field forward requires testing smaller elements of an intervention, such as single elements of an interface, rather than an entire system. The results of a multi-element intervention inform us about how successful that strategy is, but does not evaluate which components are responsible for the success. Understanding the role and influence of different elements in technology is essential for improving upon existing systems. Thus, it is crucial for future research to approach seniors' relationship with self-tracking through design focused studies, that inform us about which elements of tracking systems lead to improvements in their use by seniors.

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