Maslow's Hierarchy of Human Needs and the Adoption of Health-Related Technologies for Older Adults

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Abstract Technologies are being developed and promoted with the aim of improving the health and quality of life of older adults, but often without analyzing or planning around the human needs of users. Abraham Maslow's model of the hierarchy of needs proposes that people seek to satisfy progressively higher human needs, starting with physical needs like food and shelter, and advancing through safety and security, belonging and love, esteem, and self-actualization. Each of these levels of need has relevance for aging-related technologies. Lack of attention to user needs may be one factor that explains the limited adoption of many aging-related technologies. It is important to consider the users' current levels of need, the different needs of patients and caregivers, the degrees of behavioral change expected at different levels of need, and the unintended consequences of technologies. Insights from Maslow's model can help developers, researchers, providers, and consumers in the process of producing, evaluating, recommending, and purchasing technologies for older adults. One particular challenge is that assistive technologies may undermine esteem needs by limiting independence. Scales to measure levels of need can help characterize which needs are most relevant for different individuals, and can be used to ensure that technologies address users' needs.

Keywords Aging · Gerontechnology · Technology · Assistive technology · Abraham Maslow · Human needs · Smart homes

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Introduction

Researchers and developers have recently produced and promoted technologies intended to improve the health and well-being of older adults (Bharucha et al. 2009). Examples include systems to remind people to take their medications or to exercise, wearable devices to measure physiological parameters, location monitors, communication devices, remote patient monitoring, and fall detection systems. Described as "gerontechnologies", "technologies for healthy aging", "ubiquitous health care technologies", "pervasive technologies", "smart home technologies", or "technologies for ambient assisted living", among other terms, these are intended to accomplish various aims. Some are "measuring individualized health status" (Alwan 2009), "maintaining independence" (Wilson et al. 2009), "meeting the demands of the growing aging population" (Tak et al. 2009), "improving quality of life and efficiency of health care" (Koch et al. 2009), "enhancing life" (Demiris et al. 2004), "better quality of care" (Karunanithi 2007), supporting "chronic care management needs" (Darkins et al. 2008), and "achieving the vision of user-centered preventive healthcare" (Arnrich et al. 2009).

Despite the promises of these technologies, they have not become widely used by older adults, nor has their positive effect on health outcomes been demonstrated (Martin et al. 2008; Frisardi and Imbimbo 2011). Numerous factors contribute to how technologies are adopted, involving the technologies, users, and the degree of match between them (Davis et al. 1989; Scherer 2004). Some specific barriers to the adoption of technologies geared at older adults have been identified. A study of the perceptions of leaders in aging advocacy towards technologies found a general lack of attention to user needs, and a "virtual absence of a comprehensive market and policy environment to support either the consumer or the diffusion of these technologies" (Coughlin et al. 2007). An analysis of barriers to use of technologies in United States residential long-term care settings defined barriers in four main domains: lack of information about the technologies, financial concerns, regulatory concerns, and the challenges of managing the process of change (Freedman et al. 2005). Focus groups of older adults in continuing care retirement communities identified numerous factors that would influence their projected adoption of "smart home" technologies, including their health status, physical and mental condition, the opinion of family, friends, and health care professionals, the environment in which they lived, and the type and perceived redundancy of the technology (Courtney et al. 2008). A key tension that appeared in this and other studies was between privacy concerns and the users' perceived need for the technology (Courtney 2008; Demiris et al. 2008a). Interviews with health professional and lay people about home monitoring systems suggested that the main factor associated with their adoption was the capacity of the technologies to address the social, cognitive, and physical health of the users (Beaudin et al. 2006).

In the process of developing, implementing, and evaluating technologies for older adults, little effort has been made to characterize the types of needs faced by users. While each of the technologies is speculated to provide some benefit for the individual in health, well-being, or quality of life, the underlying challenges and desires faced by the individual are often not scrutinized. For example, in the anticipated outcomes from technologies described above, the key problems are

postulated to be physical and cognitive deficits, lack of independence, diminished quality of life, low health or social support, or inefficient health care. While these are certainly important issues, we suggest in this paper that many technologies which strive to address them may not help to satisfy the real needs faced by most older adults, and may thus fail to provide personal benefits to their target users. We will argue more generally that human needs are an important factor in the adoption of technologies geared at older adults.

A 2010 edition of the journal *Sociology of Health and Illness*, with the theme "Technogenarians", evaluated various sociological and medical factors that influence older adults' acceptance and use of technologies. Two common themes from many of the studies were that technology developers often did not anticipate or address the needs of users, and that these needs greatly influenced behaviors around technologies. As a summary found, "Far from passive consumers, elders are technogenarians, creatively utilising and adapting technological artefacts … to fit their needs." (Joyce and Loe 2010) The most striking disconnect between user needs and technologies was seen in a program to use pedometers in an older adult fitness class (Copelton 2010). The health researchers expected that pedometers would allow the walkers to measure their activity, set goals, and chart progress towards goals, thus motivating exercise adherence and healthy behaviors. But the older adult walkers saw the technology very differently: they believed that the pedometers would cause participants to compete, create hierarchy, and destroy the sense of belonging in a group. The desire for sociability clearly preempted adoption a technology that could enhance physical health. Similarly, the developers of health-enhancing robots expected their users to want and be in need of help, but the older adults they surveyed strongly rejected this position, defining themselves as capable and independent, and finding the robots "obviously not for me" (Neven 2010). Even if the technologies were able to give material benefit, prospective users might reject them because they did not address their more immediate needs of sociability and independence.

We will apply a framework, derived from the work of the psychologist Abraham Maslow, that can help to explain the observations about how older adults perceive and adopt technologies. We propose that the needs faced by people influence their behaviors and, by extension, their use of novel technologies. We find that Maslow's model, which postulates a hierarchy of five levels of human need—basic physiological needs, safety and security, love and belonging, esteem, and self-actualization—can help to predict how older adults and their caregivers might adopt and benefit from various technologies. We will illustrate how incorporating Maslow's hierarchy into the planning of development of technologies can improve their utility and application.

Previous Research

Research on the anticipated adoption of technology by older adults has indicated that personal preferences and adoption are driven by perceived needs (Demiris and Hensel 2008). Theoretical work around assistive technology (AT) has recognized that "the key to AT utility is not merely its simplicity and availability… but the extent to

which it meets a user's personal needs" (Scherer 2005). Despite this recognition of the importance of user needs, little previous work has addressed how adoption of technologies by older adults depends on specific human needs, or what categories of need are most important for different individuals at different times. A search of Medline search for "Maslow aging technology" produced no results. Using the same terms in Google Scholar, we identified one article (Coughlin and Lau 2006), which briefly and anecdotally discussed how technologies can address the needs of older adults using Maslow's framework, but it significantly modifies Maslow's original hierarchy. An unpublished thesis proposed that Maslow's framework can account for how "virtual companions for later life" might satisfy user needs (Maciuszek 2005), but without a general discussion of needs and technology.

A search for "needs aging technology" and "needs geriatric technology" produced 80 articles, none of which examined categories or hierarchies of needs. Some research has delineated infrastructure-level and product-level factors necessary for successful adoption of gerontechnologies, but without incorporating the needs of the users (Botsis et al. 2008). A review of "Smart Home" applications (Demiris and Hensel 2008) categorized technologies by the type of desired outcome (e.g. safety, physiological monitoring, security, social interaction), but did not explore how needs influence their use. There has been extensive research about Maslow's hierarchy of needs and health behaviors (Darby and Walsh 1993) and employee behavior (Benson and Dundis 2003), but little of it related to aging.

Maslow's Hierarchy of Needs

How do people choose which behaviors to engage in, and which to avoid? What motivates someone to carry out certain actions, and to pick some actions over others? At what point will people stop performing a behavior? Abraham Maslow, an American sociologist, investigated how human needs influence actions, and developed a straight forward model to help predict motivation and behavior (Maslow 1970). Maslow identified five levels of need, each building on the other, from lowest to highest: physical needs, safety and security needs, belonging and love needs, esteem needs, and self-actualization needs (Table 1).

Within this heuristic, higher-level needs are not addressed until the lower-level needs are satisfied. Performance of behaviors aimed at satisfying the current relevant

Table 1 Maslow's hierarchy of needs

Level	Needs
Physiological	Breathing, food, water, sex, sleep, homeostasis, excretion
Safety	Security of body, of employment, of resources, of morality, of the family, of health, of property
Love/Belonging	Friendship, family, sexual intimacy
Esteem	Self-esteem, confidence, achievement, respect of others, respect by others
Self-actualization	Morality, creativity, spontaneity, problem-solving, lack of prejudice, acceptance of facts

need will continue until that need is accomplished, at which point the next level is addressed. People shift back and forth between needs over time, depending on circumstances. Lower-order needs have a higher intrinsic relevance, and thus stronger short-term effects on behavior, than higher-level needs: people will more aggressively and consistently seek out food and shelter than opportunities to be creative. Conditioning around lower-level needs is also stronger than around higher-level needs: a stimulus attached to the introduction or removal of a physical need produces a greater behavioral effect than a stimulus related to self-actualization.

Maslow's theory has intuitive appeal and has been used across many academic and commercial domains, but has not been generally validated by empirical evidence. Most of the research around it has been in workplace settings (e.g. Benson and Dundis 2003) rather than among groups of community-dwelling individuals. Methodological issues complicate self-reported outcomes, the measurement of conscious and subconscious motivations, and the changes that happen in them over time. While pointed criticism has questioned the foundations of Maslow's model, in particular the structure of the levels of need (Wahba and Bridwell 1976), well-conducted research studies have neither bolstered nor refuted its use as an explanatory model (Reid-Cunningham 2008). Though the specific details of the model lack evidence in methodologically sound studies, for our purposes we consider that Maslow's model has utility as a conceptual framework that can account for some key factors in older adults' perceptions and behaviors around technology adoption.

There is some evidence that Maslow's theory well explains health-related behaviors in older adults. A study of 84 community-dwelling older adults investigated the relationships between basic need satisfaction, health-promoting self-care behavior, and demographic variables (Acton and Malathum 2000). It found that three types of needs (self-actualization, physical, and love/belonging) accounted for 64% of the variance in health-promoting self-care behavior. The greater degree of needs were met, the greater the overall satisfaction. Interestingly, age was not associated with self-care behaviors or with needs. Research in older adults in Sweden has indicated that overall life-satisfaction is associated with meeting various levels of need, which fits with this model (Borg et al. 2006). Other work has found that healthy individuals have higher need satisfaction than the sick, as predicted by Maslow's hierarchy (Leidy 1994). The two recent studies about "technogenarians" described above, around pedometers (Copelton 2010) and robots (Neven 2010), illustrate how the needs of older adults have influenced their projected use of health-related technologies.

Accomplishment of needs is, importantly, different from "improvement" or "enhancement" in general domains like quality of life, health, or independence. Such constructs do not readily map onto particular levels of need. For instance, quality of life is not something that is "met" or "accomplished"; instead it is a subjective attribution that incorporates many factors, including the degree to which needs are met. Health is a complex structure with both objective and subjective aspects, and as a dynamic state cannot be said ever to be "fully satisfied". "Being healthy" is an aspect of both physical needs and security needs, but for many people it takes on a higher-level function, with specific behaviors like exercise considered integral to esteem or even self-actualization. Similarly, independence is a potential state which

allows satisfaction of other needs and may be an important element in esteem, but it is not a particular goal that can be completely accomplished.

Practically, using a needs-based framework rather than an "improvement" or "enhancement" approach helps to explain why people might not engage in behaviors (such as increasing exercise, stopping smoking, or regulating food intake) that seem objectively beneficial, good, or healthy. Maslow's theory indicates that people will not carry out activities to accomplish a goal, however beneficial, if they are consumed with needs that are higher or lower than those met by the goal. Someone may already feel secure about her or his health status and thus not spend time on exercise; someone else may be so worried about financial security that she or he will not take steps to increase esteem. Research about older adults' perceived needs for smart home technologies well illustrates this point—respondents who had even severe objective functional impairments did not think that they were "bad enough" to need assistance, and most of them thought that others would have greater need for assistance than themselves (Courtney et al. 2008). In other words, even though a technology might give them some potential "improvement", it did not provide benefit in the areas which the users considered valuable. The disconnect between needs and what technologies offer may explain the primary dilemma discovered in this research, that "older adults who might benefit the most from smart home technology would be the persons least likely to adopt it." (Courtney et al. 2008). Clearly a behavioral model which assumes that people perform whatever activities offer them the most global benefit is insufficient to explain real-world interest in or adoption of technologies.

Levels of Need and Technologies

Each of Maslow's five levels of need has implications for technologies developed for older adults. We will review each level of need in turn, discuss how individuals seek to address it, and explore how technologies might promote or undermine efforts to satisfy it.

Level 1: Physiological Needs

The motivation to acquire food, water, and shelter is high, and behaviors that secure them are strongly reinforced. Most people do not require assistance in this process, but some, especially those with cognitive impairments, may not be able to meet physical needs consistently. Technologies in this domain, such as reminders about how to find, prepare, or serve food, or how to return home, would be expected to offer immediate rewards to the user, and to be highly reinforced. The process of satisfying such elemental needs may be contrasted to health-related behaviors with no immediacy, such as brushing one's teeth (which is mainly undertaken to preserve long-term health) or washing one's hands after using the bathroom (which does not directly benefit the individual, but is for the common good). Taking medications can help to ensure a person's long-term well-being, but typically does not satisfy an immediate physical need, especially when the medications treat chronic disease. Maslow's model suggests that individuals would adopt technologies aimed at

securing food or water differently from those aimed at better hand-washing or medication adherence.

In most cases, people are able to satisfy their physical needs, at least with some assistance from others, without any type of technology. The technologies which assist with the physiological needs of breathing, eating and drinking, sleep, and bodily functions, are geared mainly at individuals with specific physical disabilities rather than older adults. But even in this setting, research about the effects of assistive technologies on functioning among people aging with a disability has found that individuals use assistive equipment (most of it relatively low-technology) largely in order to maintain independence as an alternative to relying on personal assistance—the issue is not the physical needs themselves, but being able to "do it myself" (Wilson et al. 2009). Other research about assistive technologies for people with disabilities has exposed a tension between independence and the receipt of help, and has found that up to one-third of all access technologies are abandoned, even if they are effective; many users feel that using these technologies makes them appear helpless and challenges their self-image, and others do not want to stop receiving human assistance (Scherer 2004). These lines of evidence suggest that the adoption or rejection of technologies which help with physical needs may hinge not on the properties of the technologies, but rather on how their use fits with the users' attention to the higher-level needs of independence, belonging, or social participation.

Level 2: Safety and Security Needs

When physical needs are met, people seek protection from physical and emotional harm. Older adults reflecting on the use of monitoring technologies expressed that "relieving personal worries" would be a main projected advantage of their use (Mann et al. 2001–2002), mainly in the realm of safety and security. This level of need has both short-term consequences, like staying away from dangerous environments, and long-term consequences, like trying to build a safer world. These are more abstract needs than food, water, and shelter, and require some projective reasoning in order to continue to seek them. While there is an innate understanding of hunger, thirst, or exposure to the elements, it can be hard to recognize and adapt to subtle threats to safety or security. The types of conditioning associated with these needs are also considerably different than with physical needs, because the rewards of getting food are immediate and visceral, but the need for security is generally known only when it is threatened or lost.

Technologies to stop people with dementia from wandering away from home could be considered to improve safety and security. Yet the benefit from using such technology is conditional on understanding potential risks of going into unsafe or unknown environments; the technology does not directly change the environment to make the user feel safer. In other words, while a technology to stop wandering might change the *objective* safety of the user, it would not necessarily improve the user's *sense* of security or safety. It might, however, increase the sense of security of the caregivers, who would worry less about their loved one coming to harm. Health care providers who treat older adults anticipated this as one of the benefits of monitoring technologies (Thompson and Thielke 2009). As discussed further

below, it is important to differentiate whose needs are being satisfied, and a technology to stop wandering might address the caregiver's more than the patient's need for safety and security.

It is also important to assess the degree to which potential users feel that their safety and security needs are currently unmet. A study of the perspectives of older adults considering the use of technologies found that the expectation of security may be a default position, and that people feel safe unless they are threatened (Courtney et al. 2008). Many participants in this study thought that they would need a smart home technology if and only if their condition made them unable to handle matters as they currently did, suggesting that only insecure people would need a technology: 'I'm glad for the people who are fearful, and I think, in a way, it's a kind of fear of what's going to happen that makes you want [it, i.e. the technology]—and I can't live that way. I never have." The insecurities that attend chronic or terminal illness or financial hardship, and which may undermine life satisfaction (Borg et al. 2006), are unlikely to be addressed directly by technologies, and may thus not help satisfy security needs.

Most treatments for chronic health conditions and diseases are intended to satisfy safety and security needs, since they promise long-term well-being or health. From the health care provider's perspective, taking medications and managing vital physiological parameters like blood sugar or blood pressure might seem to satisfy elemental physical needs. Yet these steps often do not have any direct effect on how patients feel or evaluate their own health status, and may cause unintended negative effects. Research about medication adherence, for instance, suggests that patients do not perceive medications as elemental needs, and frequently miss or alter doses (Osterberg and Blaschke 2005). Medications are often expensive, and for those with little resources spending money on them can undermine financial security. There may also be competing needs around health maintenance: the poor control of blood sugars in many diabetic patients may occur when the short-term physical need of hunger trumps the long-term safety goal of maintaining a healthy blood sugar. More generally, programs to encourage better management of chronic diseases often fail to accomplish their intended goals (Mattke et al. 2007). Thus we might expect that people's willingness to adopt technologies that intend to improve safety and security through health-related behaviors would be limited unless the connection between the behavior and the improved security were obvious, self-relevant, and conditioned by experience. The individual may not share the developer's and the caregiver's concerns about health, and may thus resist using technologies that aim to improve it.

The obtrusive nature of technologies, especially those that monitor private behaviors, can in some cases undermine an individual's sense of security. While most older adults who reflected on this prospect did not feel that it would stop them from using technologies (Demiris et al. 2004; Courtney et al. 2008; Demiris et al. 2008b), certain individuals, such as patients with paranoia, have expressed feeling uneasy about being watched (Stip and Rialle 2005). The social and cultural boundaries of surveillance are still being established, and there may be generational effects which make older adults more or less tolerant of systems that track their behaviors. Maslow's model suggests that the insecurity that arises out of being watched by a surveillance technology might impair one's capacity to satisfy security needs and to progress to higher-level needs.

Level 3: Belonging and Love Needs

The next level of need is feeling loved and accepted by others. People desire communication and attachment, and seek out opportunities to relate meaningfully with others, especially family. Modern communication systems have made it possible to relate with others across space and time, and many health-related technologies have capitalized on that, as by allowing virtual presence (e.g. digital images of loved ones shown with information about them), asynchronous communication (e.g. voice messages that can be left at any time, to replay on a schedule or with prompting), or social networking (e.g. websites where people can share information about themselves). The ability to connect by telephone, e-mail, or social networking sites clearly increases opportunities for belonging. Families of patients with cognitive impairments often look for ways to satisfy belonging and love needs for their loved ones, remaining "virtually" attached across space and time. The rewards around belonging and love are immediate and direct, and patients with even significant cognitive impairments appreciate human contact. In fact, in many cases of dementia, patients show little concern for safety and security, but seek out human contact, and may show behavioral problems when deprived of it (Scholzel-Dorenbos et al. 2010) Technologies that allow virtual presence might thus bolster belonging and love without the demands of real physical presence.

It is also possible that technologies themselves could substitute for human contact. The success of some companion robotic pets or socially assistive robots (Fong et al. 2003), indicates that cognitively impaired patients may have belonging, intimacy, and attachment needs that can be met by technologies. Yet it is unclear whether machines can create a true attachment with humans. A survey of health care professionals' attitudes towards robot assisted health care suggested that "robot-assisted tasks must involve a certain degree of human caring" (Goransson et al. 2008).

While communication technologies help satisfy love and belonging needs, there has been little development of technologies that specifically foster social interactions (Demiris and Hensel 2008). Nonetheless, love and belonging may be a key unmet need for many older adults; loneliness is a common experience, and the growth of social networking websites for older adults may attest to their eagerness for even virtual connection with others.

Level 4: Esteem Needs

People seek to have confidence and to be respected. Materially, this involves completing activities that an individual considers valuable. Restricting someone's agency for carrying out such activities can undermine her or his esteem. Likewise, being given help for tasks for which one feels completely capable can be frustrating. For example, older adults often become upset if they are advised to move out of their own homes into assisted living or nursing facilities, where they will have less responsibilities but readier satisfaction of physical and belonging needs. The reluctance to give up independence indicates that esteem may be a predominant need for these individuals.

The importance of agency in esteem may create problems for technologies that seem to supplant the individual's capacity to "handle it myself". Technologies which give "help" in certain tasks would not be expected to be adopted by people who see themselves as not needing any help. Examples of overbearing software design, such as the "Clippy" office assistant (Luehning 2001), illustrate how frustrated people become when they are told that a machine knows better how than they do how to accomplish a task. Although one might suppose that older adults would appreciate assistance in their activities, research has shown that many people aging with disabilities seek to maintain independence rather than accepting the care of others (Wilson et al. 2009). Some older adults who reflected on the use of smart home technologies felt that acceptance of the technology could be "an acknowledgment of their frailty to themselves and others" (Courtney et al. 2008). Older adults who reflected on robotic technologies to improve health believed that they might be useful for other people who were incapacitated or lonely, but they were careful to characterize themselves as healthy and able, renderingthe technologies "obviously not for me" (Neven 2010). Similarly, frail older adults expressed that monitoring technologies would be useful for "the person who absolutely needs it", but not for themselves (Mann et al. 2001–2002). In this way, even if a technology provided material benefits, it might also threaten esteem by restricting agency or creating a sense of dependence or incapacity.

The potential effects of technologies on esteem are likely not inherent in the technologies, but are rather associated with contextual and interpersonal effects, especially their intended use. Intention may be endogenous, exogenous, or autogenous (Fogg 2002). With "endogenous" intent, the technology functions primarily to encourage a specific change in users, but without the user's direct investment (like an actigraph, which senses degree of movement, and tells the user to exercise more or less, based on accepted parameters). In "exogenous" intent, another individual besides the user promotes a technology in order to change a behavior (like a physician providing a pedometer to a patient to encourage walking). "Autogenous" intent assumes that the individual acquires and uses a technology to accomplish her or his own deliberate aims (like a person buying a pedometer at the store with a plan to use it in order to exercise more).

Esteem needs would be most likely satisfied in autogenous intent (the technology is a tool to accomplish a personal goal), but might be thwarted if the intent belongs to another person (like when the person who developed the technology or who prescribes its use is its main proponent, regardless of the user's wishes). For example, technologies that purport to know more than the user about the users' health behaviors, or directed rather than encouraged change (for instance with frequent strong reminders to stop smoking or exercise more) could meet with resistance because they appear to undermine users' capability to care for themselves and manage their own health.

Health-promotion strategies often promise enhanced self-esteem as a beneficial consequence of participation, such as the positive sense of having managed one's own health that comes out of exercising, managing blood sugars, or eating more healthily. The reward messages from health-related technologies are likewise often phrased around esteem: "Way to go! You did great for walking a mile today!" This feedback would be expected to motivate mainly those users who are working to

satisfy esteem needs. Yet as we have seen, other lower-level needs may take priority, for instance if one did not feel secure or a sense of belonging. In this case, the unsatisfied lower-level needs would render esteem needs and the feedback around them less relevant. This notion, which grows out of Maslow's hierarchical model, could explain why esteem-focused reinforcement might fail to achieve benefits in many health-related behaviors. We will further discuss the challenges of using technologies to improve health below.

Level 5: Self-Actualization Needs

The highest level of human needs involves being true to one's own nature and seeking self-fulfillment through creativity. Self-actualization can be achieved when all the other levels of need have been satisfied, by engaging in activities which give a sense of being truly alive or participating in something with broader meaning. Artistic pursuits, professional work, altruistic activities, group endeavors, and hobbies are all ways of meeting this need, as are mature and tolerant approaches to coping and interacting.

The motivations for self-actualization behaviors are, in Maslow's hierarchy, quite different than the motivations for behaviors directed towards others needs, since they are not carried out in order to accomplish another end (e.g. food, water, belonging, a sense of security), but are rather ends in and of themselves. As such, most self-actualization needs are not strictly health-related. While a healthy lifestyle could be considered part of a larger process of being self-aware and self-actualized (Maddux 1997), most current health-related technologies do not address self-actualization needs directly. These are by definition abstract, profound, and individualized: each person finds her or his own means to feel self-actualized. Self-actualization, as a process, is not pursued through formulaic reminders or simple behavioral suggestions, nor will one person's self-actualizing activities necessarily meet another person's self-actualizing needs. Existing aging-related technologies are focused more on material actions or states rather than profound personal concepts such as self-actualization. The process of self-actualization through technologies may thus be fraught with difficulties, since the goals and methods are highly personalized and hard to measure, although advances in human-computer interaction may open new opportunities in this domain.

Discussion

Technologies developed for older adults intend to help users accomplish various broad ends, such as "good health, independent living, and full social participation" (de Kort et al. 2005). In the future, they may be integral to these goals. Yet our review indicates that many existing technologies are poorly matched to the real needs faced by prospective users. We propose that the degree to which a technology satisfies a user's needs is a key factor in its adoption, in addition to other factors such as cost, reliability, ease of use, and accessibility.

Maslow's hierarchy of needs assumes that individuals address one level of need at a time, and when one level of satisfied, they move to the next. Most of the

technologies we have considered strive for general benefits such as health, well-being, or life satisfaction, but they neither ascertain the specific needs of their prospective users, nor work to satisfy directly any particular level of need. As such, one would expect low adoption of many such technologies, especially those with a high degree of mismatch with real needs. Moreover,when scrutinized, these technologies may not even produce their promised benefits for health status. For instance, a recent Cochrane meta-analysis of smart home technologies disclosed no rigorously conducted studies showing how technologies impact individual health status or health care variables; most of the deficits related to lack of research and real-world trials (Martin et al. 2008). An even more recent review of technologies for demented patients found a lack of any evidence of effect on health outcomes (Frisardi and Imbimbo 2011). Our findings encourage both additional research about the effects of technologies on health status, and the use of specific outcome measures to assess the satisfaction of users' needs.

An example illustratesthe disconnect between technological approaches and the satisfaction of needs. One of the most common approaches to improving health and independence through technologies uses behavioral monitoring and reminders. For instance, a sensor system or remote patient monitoring system (Darkins et al. 2008) can ascertain if the user had engaged in some health-related activity as prescribed, and if the userhas failed to complete the task, it issues a reminder. Medication adherence is the most straightforward instance: a technology can determine if the user has taken a pill at the specified time, and if this has failed to happen, or has happened too early or too late, it can inform the user of the problem. ("You didn't take your pills this afternoon. Please take them.") One might intuitively expect that such a system would, by improving medication adherence, improve health.

Yet our exploration of human needs indicates that reminders would benefit mainly those individuals who are striving to satisfy the level of need associated with physical health maintenance, namely the second of Maslow's needs, safety and security. Yet most people feel relatively safe and secure even if they miss doses of medication (as discussed above, around adherence), and a reminder would not be anticipated to enhance their sense of security. As we saw, technologies that appear to diminish the agency of users can undermine esteem needs. Reminder systems thus often create annoyance, and can quickly lead to "alert fatigue" (Cash 2009; Gouveia 2010). In this way, a technology to remind individuals about a "healthy" action might, with the aim of improving their security, undermine their esteem needs. People in this position would naturally adopt a reminder technology reluctantly and inconsistently. There may be other individuals who are concerned about taking medications exactly as prescribed, and for them a reminder technology would be expected to satisfy needs and to be adopted more readily.

Levels of need clearly do not explain every aspect of how older adults perceive, use, or benefit from technologies, but we suggest that they are an important factor in assessing and predicting motivation and behavior around technologies. In the context of the other factors which influence adoption, we propose that users will be less likely to use technologies whose application satisfies levels of need that are higher or lower than their current level of need. Technology developers, researchers, health care practitioners, and consumers should thus consider their prospective users' levels of need in producing, testing, evaluating, recommending, and purchasing

different technologies. We offer some specific recommendations for how to accomplish this end.

How Incorporating Levels of Need Can Improve Technologies

Development and successful adoption of technologies will depend, among other factors, on identifying and responding to the needs of potential users. Based on the discussion of Maslow's hierarchy of needs, we offer the following suggestions for how technologies can be planned, tested, and implemented:

1. **Technology development should account for levels of need.** It is useful to consider explicitly how a technology aims to satisfy particular levels of need. Which levels of needs are being addressed? How are they currently (without a technology) addressed? What types of patients are working to satisfy these needs? Will the technology fully satisfy a particular level of need, or are there other factors (either human or technological) required? Are all the lower-level needs assumed to be addressed? Answering these questions can help to target technologies at specific audiences, and ensure that the technology will accomplish a benefit for individuals. For instance, research suggests that many older adults feel insecure about their finances (Borg et al. 2006), yet technologies have not focused on this type of need. Likewise, technologies for individuals with dementia have largely ignored the outside public environment (focusing instead on indoor activities), which is integral to how they seek to lead their lives (Brittain et al. 2010). Technology developers might apply demand-side approaches to help older adults deal with needs that matter most to them.
2. **Needs can be measured.** Despite the somewhat abstract nature of Maslow's theory, instruments exist which can specify the need status of an individual. The Basic Needs Satisfaction Inventory (Leidy 1994) uses 27 items, with subscales derived from Maslow's theoretical descriptions. Participants answer on a scale of 1 (*terrible*) to 7 (*delighted*) about how they feel about various aspects of their lives. This instrument shows excellent validity and reliability (Irvin and Acton 1996). There are some unexpected results on this scale in different populations, and considerable variability in the levels of needs addressed by people with the same health conditions (Wilson et al. 2009); therefore it is important to measure rather than to assume the needs faced by different individuals. Using such scales can help target technologies to the real needs of older adults.
3. **Clarify whose needs are being addressed.** The needs of caregivers and patients are usually different, and sometimes at odds. Many patients with cognitive impairments describe having no complaints, while their caregivers are exhausted and unable to find any time for themselves (Gaugler et al. 2004). Some technologies used by or on a patient (for instance, to encourage a more structured sleep rhythm, to issue reminders, or to prevent wandering) can primarily address the caregiver's needs (the physiological need for his or her own sleep, or for security). The individuals' different categories of need can influence how patients and caregivers use technologies. For instance, in patients with Alzheimer's dementia, caregivers often have much greater difficulty

satisfying their needs than do patients, including basic needs such as sleep and social participation, and caregiver-focused technologies may be adopted more readily than patient-focused ones.

4. **Needs influence adoption.** As described in the introduction, many technologies are developed to make general or high-level "improvements" in people's lives, like health, life satisfaction, or well-being. We have argued here that people will not engage consistently in behaviors which do not satisfy the specific needs which apply to them at a particular time. No matter how powerful, unobtrusive, inexpensive, or intelligent a technology is, people will be unlikely to adopt it if it works to satisfy a need that is above or below the one that is relevant for them. Therefore developers and promoters should cautiously frame anticipated benefits and uptake around the specific needs faced by users.

5. **Levels of need change and progress.** Maslow's hierarchical model suggests that people address one level of need at a time, engage in activities to satisfy that need, and then move to the next. Most existing technologies developed to help older adults work to solve a chronic problem reliably and repeatedly (such as encouraging routine participation in a health-related behavior like exercise, increasing social connection on a regular basis, or ensuring safety). Use of the technology is assumed to continue as long as the patient has the same underlying conditions or functional status. But counter intuitively, Maslow's model indicates that successful use of a technology could result in diminishing use: if the technology satisfied the need, the user would be expected to progress to a higher, and categorically different, type of need, and thus no longer consume the technology. For instance, people might attend to reminders about taking their medications while they are addressing a need for security, but when they feel that they have done enough in this realm and are secure, they might ignore the reminders or become annoyed with the reminder system. The frustration that competent computer users feel toward simplistic reminders from a computer assistant like "Clippy" (Luehning 2001) illustrates how the indiscriminate application of a technology to address one level of need may undermine progress towards higher-level needs.

6. **Consider unintended consequences:** The example of how monitoring and feedback technologies can undermine esteem (by making the users feel that they are incapable of doing it themselves) shows how a technology aimed at producing one benefit could jeopardize satisfaction of another need. For instance, older adults strongly resisted the idea of health-enhancing robots for themselves, identifying themselves as physically healthy, independent, and helpful, yet the technology developers imagined them as elders in need of help (Neven 2010). We also saw how surveillance technologies can jeopardize an individual's sense of security, because they feel "watched". Technologies may also encourage reliance on machines rather than in-human interactions, which could reduce people's sense of belonging and love. Technologies can change how patients and caregivers interact on a day-to-day basis, and in some cases monitoring technologies could result in the caregiver showing less vigilance to their loved one (Demiris and Hensel 2008). Measuring satisfaction of all levels of need before and after adoption of a technology could help to identify unintended consequences of its use.

7. **Consider the needs addressed by nonspecific goals.** Although good quality of life, health, and independence are noble aims, they do not ensure benefits for the individual in her or his efforts to satisfy needs. As such, in Maslow's framework these nonspecific categories would not help to plan or predict the adoption of technologies, and would also make it difficult to measure specific outcomes. Two of the goals which technologies claim to improve, independence and health, deserve particular attention.

   a. **Independence:** Increasing independence is a common aim of technologies for older adults. Our discussion suggested that independence relates mainly to esteem needs—the capacity to do things oneself—which raises several challenges for efforts to enhance independence. First, this is a relatively high-order need, and may not apply to people who cannot satisfy physical needs, feel insecure, or lack social connectivity. Second, technologies that remove control from people can undermine esteem by not letting people function independently. For example, independence is not achieved by, and may even be undermined by, providing feedback about an individual's status to someone else, such as in a real-time report about functioning (medication adherence, eating, activity, self-care) sent to family members or caregivers. Third, adopting technologies can negatively impact one's self-image, especially if one is seen to rely on them (Scherer 2004). Attention to the context and meaning of independence, and exploration of how older adults satisfy esteem needs, might thus encourage development of technologies which address user-level needs more directly.

      One of the postulated goals of many technologies is to foster independence by letting older adults remainin their own homes (Martin et al. 2008). Being in one's home can satisfy security needs, and in some cases the need for belonging, esteem, or self-actualization. Yet in many circumstances, especially when a person lives alone or cannot manage the all of the requirements of sustaining a household or the independent activities of daily living, being at home creates a significant burden in time and energy. Independently shopping, cleaning, cooking, and taking medications mainly satisfy physiologic and security needs, but may not leave sufficient time or energy to pursue other aims. Often when patients move out of their homes into assisted living facilities they can engage in more social pursuits and participate in interesting activities. In other words, remaining at home can sometimes impair the opportunity to address higher-level needs. Technology developers might thus consider the broader context of how technologies to remain home impact the types of needs which an individual faces, rather than assuming that remaining at home has intrinsic value for everyone and at all times.

   b. **Health:** Health is difficult to define, and "health promotion" can have a wide variety of meanings and address very different needs. First, it is important first to characterize what health means in relation to the technology: is it absence of disease, presence of physical, mental and/or social well-being, participation in specific activities, or a holistic concept related to reaching one's personal and social potential in life (Beddington et

al. 2008)? Depending on which of these is meant, very different levels of need become relevant. Second, what type of health need is unmet? Is the user even worried about her or his health? Does the individual want to change his or her behaviors? Is a specific behavior to be changed, or is the goal to improve knowledge generally? Is the intention to meet a health-related need endogenous, exogenous, or autogenous to the individual? Different contextual factors will greatly influence how people will adopt various technologies around health, and will alter the effects of different types of technology-driven feedback. Third, how do other needs compete with the goal of health promotion? The example of pedometers in a walking group well illustrates how the need for belonging preempts the use of a technology that might increase health gains: the older adult walkers saw monitoring through pedometers as "anathema to walking group norms that stress sociability" (Copelton 2010), and chose not to use them. It may seem illogical for individuals to resist a technology which could improve their health, but this behavior may be perfectly natural given the other relevant needs which they face.

Conclusions

Maslow's hierarchy of needs provides a useful framework for considering some of the key aspects of how technologies developed for older adults might be adopted and applied. It suggests that many technologies which intend to improve quality of life, health, and independence may not address the specific needs which are directly relevant for individuals. We propose that users will be unlikely to adopt technologies which do not address their current needs, although various other factors related to the technology and the user also influence adoption. Greater attention to human needs could help developers, researchers, providers, and consumers to produce, apply, and use technologies with the most utility for aging adults.

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