A New Research Challenge: Persuasive Technology to Motivate Healthy Aging

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***Abstract*—Healthcare systems in developed countries are experiencing severe financial stress as age demographics shift upward, leading to a larger percentage of older adults needing care. One way to potentially reduce or slow spiraling medical costs is to use technology, not only to cure sickness, but also to promote wellness throughout all stages of life, thereby avoiding or deferring expensive medical treatments. Ubiquitous computing and context-aware algorithms offer a new healthcare opportunity and a new set of research challenges: exploiting emerging consumer electronic devices to *motivate* healthy behavior as people age by presenting "just-in-time" information at points of decision and behavior.**

***Index Terms*—Behavioral science, geriatrics, medical services, persuasion, user interfaces.**

I. The Problem

THE U.S. medical system, like that of many other developed countries, faces an impending crisis: How to pay for the care of elderly adults. By 2020, the U.S. Census Bureau projects that over 30% of the U.S. population will be over the age of 50 [1]. The increasing percentage of older adults, combined with governmental healthcare shortfalls and the rising cost of medical procedures, will place an enormous economic strain on the U.S. healthcare industry in the next two decades.

Healthier lifestyle decisions related to diet, exercise, dental care, stress management, and maintaining social relationships are known to positively impact overall quality of life and long-term health. Technologies that can successfully motivate long-term healthy decision-making could delay or even prevent the onset of medical problems such as obesity, thereby alleviating financial pressure on the traditional medical system. Obesity, for instance, has been identified as an independent risk factor for coronary heart disease, hypertension, Type 2 diabetes, stroke, gallbladder disease, osteoarthritis, sleep apnea, and several types of cancers [2].

II. Just-In-Time Messaging and Behavior Change Motivation

Two ubiquitous computing trends are converging to create a new preventive healthcare opportunity. The first trend is the rapid adoption of powerful mobile computing devices. Mobile phones, personal digital assistants, and watches are becoming sophisticated mobile computing devices that can collect and process sensor data from wearable wireless sensors and convey information to a user via audio and bright liquid crystal display (LCD) touch screens. Future devices will be smaller, lighter, inexpensive, and available in a variety of convenient form factors (e.g., wristbands). Mobile computing devices are carried nearly everywhere by an increasing percentage of the population and can, therefore, be used to convey motivational health messages at an *appropriate place*.

The second ubiquitous computing trend that will lead to this new preventive care opportunity is the emergence of real-time context-aware computing. A context-aware computer system can automatically infer what a person is doing from sensor data. The user's activity can then be used to present a health-related message at an *appropriate time*—specifically, a point of decision or behavior when an easy-to-understand message might have an impact on behavior. For example, two or more accelerometers worn on the body can be used to infer posture, ambulation, and various household activities that involve physical activity (e.g., scrubbing, vacuuming) [3]. Soon, these activity detection algorithms will run on mobile phones and acquire sensor data from wearable wireless accelerometers attached to objects worn or carried such as watches or key chains. Sensors placed in the home may allow other everyday activities (e.g., cooking) to be automatically detected as well [4].

These two trends will enable a new class of *just-in-time* persuasive interfaces to be created that motivate behavior change by providing well-timed information to users at points of decision, behavior, or consequence [5]. Researchers in a variety of non-information technology fields have convincingly demonstrated the power of point-of-decision messaging to motivate behavior change (e.g., improving workplace safety [6], encouraging seat belt usage and public recycling [7], reducing electricity consumption [8], and encouraging exercise in public spaces [9]). Although the systems only work for some of the people, some of the time, studies have consistently shown that context-sensitive information presentation can alter behavior (e.g., doubling the number of people who take stairs [9], reducing air conditioner use by 15% [8]).

A review of the preventive health prompting literature suggests that there are four components to an effective strategy to motivate behavior change using just-in-time information: 1) present a simple, tailored message that is easy to understand, 2) at an appropriate time, 3) at an appropriate place, 4) using a nonirritating strategy (even after possibly hundreds of presentations).

Context detection algorithms provide information that can trigger messages at an appropriate time, and mobile computers allow message presentation at the appropriate place. Mobile computers are also becoming personal archiving devices,

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recording sensor data about user experience, such as where the user goes and what the user does [10]. These databases can, therefore, be exploited to *tailor feedback* to a person based upon past experiences and the current context. Prompts that are not only timely but tailored to the individual are known to be most effective at motivating behavior change [11].

The fourth criterion for effective prompting—presenting information in a nonirritating way—may be the greatest ubiquitous computing challenge. One way to minimize the likelihood of a message becoming annoying is to ensure that each message has a high perceived value to the user and that it does not appear to be judgmental. This is a challenging design goal because the tendency when developing computer systems that motivate behavior change is to gravitate toward solutions that present messages to the user telling him or her what to do and when. For example, computerized nutritional kiosks developed by health professionals tell users to buy one product (e.g., skim milk) instead of another (e.g., whole milk). Similarly, telephone linked care systems provide strong recommendations on what to eat, how to get exercise, and how to take medications. Both types of systems have proven effective in clinical trials [12], [13]. Notwithstanding the results of these studies, however, most people feel strongly that a computer making suggestions about what they should be doing is not a computer system they wish to be using over a long period of time.

III. Challenges

A key challenge when creating an interface to motivate healthy behaviors, therefore, is to abandon heavy-handed approaches where the system detects what the user is or is not doing and then tells the user what to do. Consider a persuasive technology designed to motivate brisk walking. One strategy would be to use sensors such as accelerometers to monitor when and how a person is walking and when that person is not walking to then encourage him or her to start. This places the computer device in the position of telling the user what he or she should do. People who have a high external motivation to get more exercise from walking, perhaps due to a recent medical condition, may respond positively to this technique. People who consider themselves to be healthy, however, may find that over time the system's directions become irritating, invasive, and burdensome. To eliminate the burden, users can simply turn off the device. An alternative design approach is to leave all control for decision making with the user (i.e., never recommend a particular type of action) but instead to provide just-in-time information highlighting the benefits of engaging in particular behaviors [14]. Further, by automatically detecting when the user engages in healthy activity, the computer can instantly reward that behavior, using the powerful motivational strategy of positive reinforcement operant conditioning. A computer that encourages behavior with positive reinforcement and user self-awareness, without guilt-inducing directives, is less likely to generate user resentment and to be disabled because of user frustration.

At the Massachusetts Institute of Technology, prototypes of context-aware systems for motivating brisk walking, motivating stair usage in public spaces, motivating less television viewing, motivating social connectedness, and motivating better dietary decision making have been constructed. We are striving to overcome the following challenges.

Achieving subtlety. Systems to encourage healthy behavior must operate longitudinally, for months or years because many behaviors take a long time to change. Therefore, the technology must maintain a sufficiently high perceived value with the user so that use of the technology is not discontinued. Individual messages, which may be presented hundreds or thousands of times in a year, must balance subtlety (so they can be easily ignored) with motivational influence (so they lead to behavior change). Presentation of information may need to adapt over time as the user habituates to particular motivational strategies.

Detecting the right time. Certain behaviors such as physical activities lend themselves toward automatic detection by computer. Others such as food consumption, however, may require more input from the user to monitor. Activity inference algorithms will generate false positive and false negative results. Research is needed to determine how these imperfect context detection algorithms can be integrated into the user interface without creating confusion. Further, the sensors required to detect the activities must not burden the user, stigmatize the user, or jeopardize the user's sense of privacy.

Sporadically interacting in time. The opportunity to present messages at points of decision and behavior may be fleeting, occurring at brief moments intermixed with everyday life. Just-in-time messages must be conveyed quickly, and information dispersal will take place in sporadic bursts not in longer sessions, as is common with desktop computer interfaces.

Avoiding over-reliance on external justification. A motivational technology will, ideally, lead to long-term sustainable behavior change even if use of the technology is discontinued. Interfaces that motivate behavior using only external justification (i.e., timely rewards) may lead to behavior change that dissipates over time if the external incentives are removed [15]. Interfaces that encourage behavior change with just-in-time prompting may also need to promote attitude change to ensure long-term results.

Leveraging consumer technologies. Health messages can be delivered today at a low cost utilizing telephony [13] because consumers purchase the technology for other purposes. Similarly, computer systems that motivate behavior change using just-in-time techniques will be most economical if they can exploit consumer sensor and computer technologies purchased by consumers for reasons other than healthcare (e.g., sensor-enabled phones for communication and/or games).

Motivating the "healthy." The earlier in life an individual makes healthy behavior changes, the more impact those changes will have on preserving health. A challenge, therefore, is to design just-in-time preventive health technologies for people—old and young—who do not consider themselves to be sick. These people will use the technology only if it improves feelings of self-efficacy, well-being, or security without becoming a burden. To do so requires that the sensor infrastructure require almost no proactive action from the user. What little maintenance that is required (e.g., remembering to wear a sensor watch) must be balanced against interaction elements that generate feelings of high perceived value. Motivational applications may need to incorporate elements that are fun,

humorous, creative, or inspirational to entice users to keep using them.

Proving efficacy. The greatest challenge when developing user interfaces that motivate behavior change for healthy living is evaluation. Technology is needed not only to motivate the behavior change but also to monitor if behavior actually does change. Interfaces that are heavy-handed may lead to short-term gains but in the long-term fall into disuse. Will a system with subtle just-in-time feedback work in practice? The behavioral science literature suggests that it will work, but answering this question requires long-term large-n studies.

In summary, new ubiquitous computing technologies may enable a new class of consumer electronics devices that use "just-in-time" presentation of information at points of decision and behavior to motivate behavior change. The new opportunity is to exploit the computer's ability to detect the best time to provide feedback and to provide it in a way that is tailored both to the user and the situation. If such feedback could be delivered longitudinally, without aggravating the user, it could lead to slow but steady behavior change that improves quality of life and health for the user.

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