ALZHEIMER RESEARCH FORUM — NETWORKING FOR A CURE

Technology in Dementia Diagnosis, Care

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By Madolyn Bowman Rogers

Will Technology Revolutionize Dementia Diagnosis and Care?

As populations age worldwide and the number of people with dementia is set to soar over the next few decades, a crisis in eldercare looms. At the same time, the use of personal technology—smartphones, tablets, wearable monitors—is exploding. Can technology help society avert the crisis? Some researchers envision a future in which older adults with cognitive decline or Alzheimer's disease could stay independent longer with the help of technology. Robots and interactive computers would aid an impaired senior to complete simple tasks. Monitoring systems would send an alarm to relatives if the person fell, skipped medication, or was otherwise in difficulty. Interactive computer games and online communities tailored to people with dementia would provide cognitive and social stimulation that might slow decline. Sound like science fiction? These ideas are being tested now in research studies. Some of the technology is on the market, and much of the rest may become available within the next three to five years, researchers predict.

It remains to be seen how well this technology will work. How comfortable will AD patients and their families be with it? What problems will it bring? As with other technological advances, society will grapple with the question of how to maintain dignity, privacy, and the carer's human touch as machines become more integrated into our lives.

Technology for the Elderly

In 2005, the Center for Aging Services Technologies (CAST), an international coalition of technology companies, research universities, and aging services organizations, produced a video for the White House Conference on Aging. It showed how a hypothetical family might care for an aging relative in the future (view video). An actor portrays an elderly man with cognitive decline who continues living alone in his home, thanks to a suite of technology. Home monitors alert his family to any changes in his health or routine. Automated systems turn off the gas stove if he forgets. Video connections allow him to chat with distant family members, and computer games help maintain his cognitive skills. When the video was made, most of the featured technology did not yet exist, said Majd Alwan, CAST's executive director. "Today, the vast majority of these technologies are a reality and are available on the market."

Technology in the home might help seniors stay independent. *Image courtesy of the LeadingAge Center for Aging Services Technologies*

Not only does such technology hold hope for improving the quality of life for people with dementia and their caregivers, it may also advance research and empower clinical trials, researchers point out. Sensitive, computer-based tests may be able to detect subtle signs of cognitive change long before clinical symptoms develop, allowing researchers to recruit preclinical patients into prevention trials. Monitoring systems will provide rich, low-cost datasets for tracking the progression of decline, enabling scientists to detect small improvements due to treatment. This will be more reliable, valid, and sensitive than current clinical assessments, which are taken too infrequently and are prone to huge variation, predicted Jeffrey Kaye at the Oregon Health and Science University, Portland. Such innovations may reduce the size and expense of clinical trials, allowing more agents to be tested, agreed Stephen Bonasera at the University of Nebraska Medical Center, Omaha.

This Alzforum series looks at the types of technology now under development and how they might be used. The featured studies are but a sample of those under development. The field of "gerontechnology" is rapidly growing, with many companies, big and small, offering products in this area. Several large research groups specialize in gerontechnology, for example, the Oregon Center for Aging and Technology (ORCATECH) in Portland and the Technology Research for Independent Living (TRIL) in Dublin, Ireland. The International Society for Gerontechnology holds a biannual conference and publishes its own journal, and the Gerontological Society of America includes a technology subgroup. The recent Alzheimer's Challenge 2012 awarded a total of $300,000 to five finalists for their technological tools to better diagnose and monitor people with AD (see ARF related news story). Alzforum invites comments on additional technologies of interest.

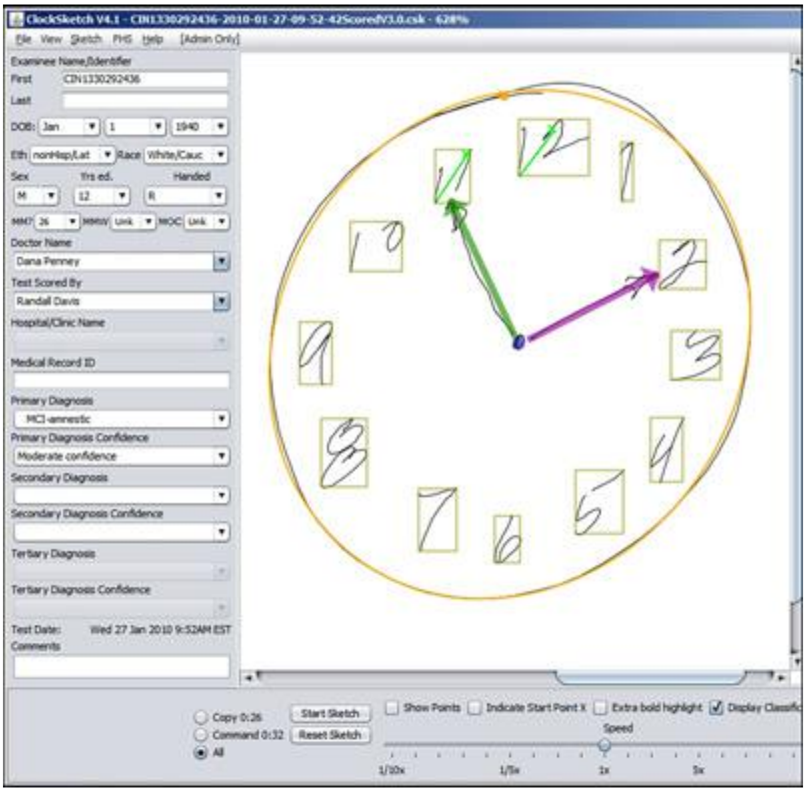
Canary in a Coal Mine: Earliest Warning Signs of AD

Computerized commercial tests, such as the Cambridge Neuropsychological Test Automated Battery (CANTAB), the Cognitive Drug Research battery, and the CogState computerized cognitive tests, are already used in research and clinical trials. They track cognitive decline and can detect treatment effects in early AD. However, with recent attempts to define a preclinical stage of AD (see ARF related news story) and growing interest in conducting preventive trials (see ARF related news story), researchers need to find more sensitive methods to detect the earliest cognitive changes. “Much of the current debate centers around what tests to use in prodromal or preclinical patients,” said John Harrison at Metis Cognition, Warminster, Wiltshire, U.K. Harrison developed a neuropsychological test battery called the NTB. He pointed out that although traditional instruments like the Alzheimer’s Disease Assessment Scale-cognitive subscale (ADAS-cog) include some memory tests that pick up deficits in very early AD patients, on most of the measures almost everyone in the mild stages of AD scores at the maximum. In other words, the ADAS-cog has "ceiling effects," so it cannot pick up improvements in response to drugs (see, e.g., Nature news story).

Many companies are therefore developing more sensitive tests, although most are not ready for prime time, Harrison said. The majority of such tests focus on measures of episodic memory, working memory, and executive function. They use repeated testing of the same person over time to detect change. This strategy picks up people with high levels of education who still score above the population mean, but whose cognition is in decline. One test gaining popularity for detecting prodromal AD is the free and cued selective reminding test (FCSRT), in which participants must remember 16 pictures, first without aid and then with the help of cues. Low scores on this test have been shown to associate with AD cerebrospinal fluid biomarkers in people with mild cognitive impairment (see Wagner et al., 2012). The FCSRT is recommended by research diagnostic criteria for prodromal AD (Dubois et al., 2010). In the future, these types of cognitive screening tests could become part of a standard annual checkup, Harrison suggested.

Another problem that dogs cognitive testing is the practice effect, where growing familiarity allows a person to improve on the test (see ARF CTAD story). Harrison claims that computerized tests beat the standard paper-and-pencil variety hands down when it comes to training effects. With computers, the test can change each time a person takes it. For example, in the Mini-Mental State Exam, clinicians often give patients the same three words (apple, penny, table) to try to remember every time they take the test. Over time, even impaired patients learn the words. Anecdotally, researchers tell of patients coming in for study visits asking, "Hi doc, are you going to test me on apple, penny, table again today?" By contrast, a computerized test can choose from hundreds of randomly generated words, so that each time patients take it, they see a different set. Digital tests have the added advantage of being able to measure things like reaction time, which provide additional clues to early impairments.

An example of this is the Digital Clock Drawing Test (dCDT) under development by Dana Penney at the Lahey Clinic, Burlington, Massachusetts, and Randall Davis at MIT. A finalist in the Alzheimer’s Challenge 2012 (see ARF related news story), this technology adapts the traditional paper-and-pencil clock drawing test to a digital format. In the paper version, clinicians suspect cognitive problems when patients cannot draw a normal-looking clock. In the digital version, people use a digitizing ballpoint pen to draw on paper; the pen then transmits the data to a computer, where the dCDT software analyzes what they draw and how they draw it. Even when the final product looks normal, the computer can detect changes in the process. People with early cognitive impairment hesitate more and spend more time thinking rather than drawing compared with healthy controls. Penney and Davis also report that the test can measure executive function by the presence of very tiny "hooklets" that occur when drawers think about making the next stroke before they finish the current one. Often only half a millimeter long, these hooklets are a good thing; their disappearance may indicate declining executive function. Early evidence suggests that the Digital Clock Drawing Test can pick up preclinical cognitive changes that correlate with atrophy in the parietal lobe, the researchers claim. Penney and Davis are collaborating with Rhoda Au at Boston University and the Framingham Heart Study to validate the test in the FHS' longitudinal dataset to see whether it can detect presymptomatic changes in people who test positive for AD biomarkers.



Clock drawn by a person with MCI appears normal, but the computer detects hesitation that betrays impairment. © *2012 Lahey Clinic and MIT*

Visual deficits are another early warning sign of cognitive decline, said Creighton (Tony) Phelps at the National Institute on Aging, Bethesda, Maryland. People in the early stages of decline perform poorly on some standard ophthalmology exams such as pattern and contrast detection, and show deficits in visual memory (see, e.g., Kawas et al., 2003; Cronin-Golomb et al., 1995). For example, a test of visual short-term memory developed by Mario Parra at the University of Edinburgh, U.K., detects memory problems in young, asymptomatic AD mutation carriers (see ARF related news story). Vision changes may precede AD diagnosis by more than a decade. They seem to reflect deterioration in the limbic system and medial temporal lobe—areas crucial for visual perception (see Rosen, 2004). Researchers in the ophthalmology industry have expressed interest in modifying their equipment to screen for AD, Phelps said.

Another type of visual impairment shows up early in the disease. According to work by Charles Duffy at the University of Rochester Medical Center, New York, people with mild AD become easily confused by objects moving through their visual field. This impairs their ability to navigate through space, as shown by a computerized test (see Mapstone and Duffy, 2010). Degeneration in subcortical structures important for navigation probably underlies the problem, the authors note. They suggest that such tests could be used to screen elderly drivers in the future. The findings fit with other work showing that visual perception falters in early mild cognitive impairment (see Newsome et al., 2012). Phelps noted that in a subset of people with AD, the visual movement deficit seems to be an early sign that precedes obvious cognitive impairment, and may correlate with posterior cortical atrophy (PCA), a variant of AD that affects the visual cortex (see ARF related news story on PCA).

These types of visual assessment, the Digital Clock Drawing Test, and other computer-based tests offer the potential to spot cognitive problems earlier than ever before. But what happens after an older adult receives a diagnosis of mild cognitive impairment, or even AD?

Tech Revolution: Monitoring and the Power of Real-Time Data

Fifteen years ago, Diane Mahoney, then at Hebrew SeniorLife's Hebrew Rehabilitation Center, Roslindale, Massachusetts, conducted one of the earliest studies of home monitoring systems for aging. Mahoney and colleagues installed a suite of simple sensors in the homes of frail elders. Infrared motion detectors recorded when someone walked by. Contact sensors revealed when someone opened a medication drawer or refrigerator door. The system sent the data to the younger relatives of the participants, and triggered an alert if something out of the ordinary happened. In one case, an alert went out when an elderly man had been motionless for an unusually long time. His relative phoned to check on him, and when there was no answer, called the building manager. The manager entered the apartment to find the man unresponsive. The manager summoned aid. The man, who had fallen into a diabetic coma, survived.

This vignette illustrates the potential of home monitoring technology to improve care. Mahoney, now at MGH Institute of Health Professions, Boston, notes that in the early days, many in the field questioned whether older adults would use the technology. Her research has allayed that concern. "If the technology is designed in a way that is perceived to be valuable to elders and caregivers, they will adopt it and be generally satisfied with the outcomes," Mahoney said (see also Mahoney et al., 2008, and Mahoney, 2010).

Today, such monitoring systems are commercially available from companies, and in use in many retirement and assisted-living communities. A leader in this field is Jeffrey Kaye, who directs the Oregon Center for Aging and Technology (ORCATECH) in Portland. Kaye is interested in the potential of home monitoring systems to provide real-time, objective data on how a person's functional and cognitive status changes over time. He believes this would produce more reliable, sensitive information than do standard clinical assessments. Current clinical assessments are done infrequently, cannot take into account whether a cognitively impaired person is having a good day or a bad day, and require the person to recall past activities. The upshot is that these assessments inaccurately reflect the person's day-to-day experience, Kaye said.

To track functional and cognitive changes in elderly people, Kaye and colleagues use a system that includes not only motion, contact, and medication sensors, as well as load sensors that detect someone lying on a bed, but also monitors social activity. This includes telephone sensors that record the amount of time spent on the phone and whether the call was likely to be personal. Computer algorithms look for words used more frequently in business calls, such as "eligibility" or "representative," versus words used mostly in casual conversations, such as "adorable," "biscuits," or "casinos." People also tend to speak more slowly during business calls, Kaye said. Software programs count time spent on the computer in video chatting or e-mail. Motion sensors track time spent out of the house, and voice sensors record time spent talking aloud, which typically reflects face-to-face conversations with other people. The sensors require no attention from the participants. Pre-empting Big Brother concerns, they do not record calls or conversations, only the minutes spent talking with others. This system was a finalist in the Alzheimer's Challenge 2012 (the iChange team). Kaye and colleagues have been testing it in more than 250 homes for over three years.

The scientists found that most of the measures of functional and cognitive status drop off over time in people with mild cognitive impairment (MCI), but not in cognitively healthy elderly. Intriguingly, increased day-to-day variability emerged as one of the earliest signs of decline, perhaps reflecting the fact that people in the early stages of AD tend to have "bad days" and "good days," Kaye said. They cannot stick to their daily routines anymore. In particular, the researchers have found that higher daily variations in walking speed predict cognitive decline (see Dodge et al., 2012). This system detects change in early MCI with greater sensitivity than current clinical methods, Kaye claimed, hence, is suitable to provide better outcome measures for clinical trials. Another advantage for researchers is that a complete home monitoring system costs fairly little—about $1,000. It provides data for years, Kaye pointed out. In comparison, an amyloid PET scan can run from $3,000 to $6,000. "There has been tremendous interest from the pharmaceutical industry in this methodology," Kaye said.

Many other groups are devising improvements on home monitoring. For example, Ho Ting Cheng and Weihua Zhuang at the University of Waterloo, Ontario, Canada, have developed a Bluetooth-enabled home monitoring system that performed well in an early feasibility study (see Cheng and Zhuang, 2010). Stephen Bonasera at the University of Nebraska Medical Center, Omaha, in collaboration with Lance Perez at the University of Nebraska-Lincoln, works on motion sensors that use radio-frequency identification (RFID). Participants stick a small RFID tag on their clothing, and every time the circuit passes through a sensor, the sensor logs it. An advantage to this system is that it could be used to independently track more than one person in the same home, because each person would wear a unique tag, Bonasera said. He is currently validating the approach.

Bonasera believes real-time monitoring could transform clinical trials. To bring down costs, researchers need a cheap, passive, continuous monitoring system that stays with a person at all times, he said. The ideal device for this already exists, he believes. It is the smartphone. The accelerometer—tiny silicon springs that move in accordance with gravity (see video)—that allows the device to switch from portrait to landscape mode also enables it to collect data on a person's movements simply by being carried in a pocket. In addition, the phone's GPS tracks the user's movement within the community. The extent of this movement defines a person's "lifespace." Lifespace tends to shrink as AD approaches, and larger lifespace has been shown to predict better health outcomes, Bonasera notes. The smartphone can be programmed to send monitoring data to a central computer at regular intervals. This methodology could be easily scaled up to follow thousands of people in a trial, Bonasera suggested.

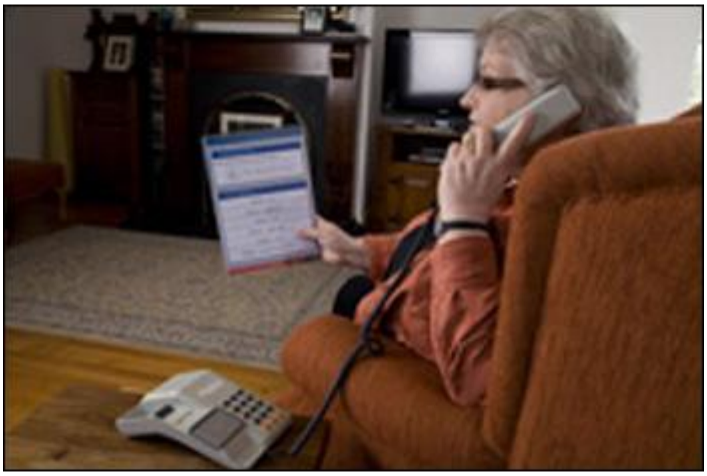
With collaborators Katrin Schenk at Randolph College, Lynchburg, Virginia, and Evan Goulding at Northwestern University, Evanston, Illinois, Bonasera has tested the validity of the accelerometer and GPS data on 100 participants. The technology provides a more accurate measure of people's activities than keeping a journal does. It can measure factors such as a person's walking speed and the number of footsteps they take, Bonasera said. He now wants to prove that this methodology can work in a clinical trial. He plans to enroll 20 participants with mild or moderate AD who are about to start taking cholinesterase inhibitors. Bonasera will record a month of data before they start medication, and compare the measures to a month of data after they start. Cholinesterase inhibitors modestly improve cognition and daily coping in people at that stage of disease. Bonasera hopes that, by using the continuous activity data, he can show a statistically significant improvement in daily functioning in a much smaller group of participants than researchers would normally need for a clinical trial. "If we can prove this concept, pharmaceutical companies and organizations might be interested in using this technology. If we can make clinical trials cheaper and enroll fewer patients, we can do more trials and test more agents," Bonasera said.

Other groups are also taking advantage of the ubiquity of cell phones. Ginger.io, a startup company with offices in San Francisco, California, and Cambridge, Massachusetts, has developed a mobile phone app that tracks people's health through a combination of passive recording (location, movement, phone use) and active self-reports. The information goes to the participants' healthcare providers to help manage and improve their health. The company is customizing the app for chronic diseases such as diabetes and chronic pain. Sai Moturu leads a project to tailor the software to Alzheimer's disease, for example, by adding cognitive tests. This project won the Alzheimer's Challenge 2012 (see ARF related news story).

Moturu noted that designing the AD app presents special challenges because users will be cognitively impaired. For example, AD patients may be unable to fill out self-reports, leading to a greater reliance on passively collected data in this population. People with AD may forget to carry their cell phones, in which case it will not collect any information. Another issue is patient privacy, said Sabih Mir at Ginger.io. For the company's other apps, patients choose to participate, retain control of their own data, and share it only with their healthcare provider. This reassures patients that their health information will not be used against them by insurers or employers, for example. AD patients may be unable to manage their own data, and need help from caregivers or healthcare professionals. Because of these obstacles, Mir could not put a timeframe on when the AD app will come on the market.

Mahoney raised the privacy concern as well. In her initial trials, caregivers resisted cameras in the home. However, after using the system for a time, “people seemed to develop a trust in us and in this technology,” Mahoney said. Users then recommended adding cameras to help determine whether an alert was real or a false alarm. “The key to it all is that the caregivers controlled whether the cameras were on or off. That seemed to allay privacy concerns.” For their part, seniors became willing to trade privacy for being able to age in place, Mahoney said. “Elders tend to embrace technology that enables them to stay in the environment they prefer.”

For seniors living at home, doctors would like to have a quick, simple way to keep tabs on their cognitive status. [The Technology Research for Independent Living (TRIL) Centre], based in Dublin, Ireland, has developed a technological approach to do this. In a project called “Dear Diary,” overseen by Richard Reilly at Trinity College Dublin, participants receive written material in the mail, then phone in to a central computer system. Participants read aloud passages of text and answer questions from their written packet. Voice processing software then breaks down not what they say, but how they say it, TRIL academic director Brian Caulfield told Alzforum. For example, people with cognitive impairment pause more during speech, speak more flatly, and have more difficulty describing a picture than do cognitively normal people. “The remote cognitive assessment methodology performs extremely well when you compare the results against a standard Mini-Mental State Exam as performed by a healthcare professional,” Caulfield said. “It is a low-cost, easily deployable system for tracking a person’s baseline cognitive function. That means we will be able to identify deviations from that baseline more easily than in the past, and therefore will be able to trigger earlier interventions.”



Automated cognitive assessment by telephone. © *TRIL Centre*

Are projects such as these only the beginning of how technology will transform assessment and monitoring of cognitively impaired people? Mahoney sees potential but voices caveats as well. As technology advances to monitor more variables, she foresees an information glut that could trigger too many false alarms. “Caregivers don’t want more data; they want meaningful data. They don’t like false alerts,” she said. As monitoring systems become commonplace and offered by telecommunications companies or home security providers, installers need to be properly trained on how to deal with cognitively impaired people. Having a stranger come into the home to install technology can be traumatic for someone with dementia, Mahoney pointed out.

At the same time, some fears about new technology have proved unfounded. In the early days, institutional review boards were concerned that installing monitoring equipment in the homes of seniors would isolate them socially, Mahoney said. Relatives would call less often because they could see via computer reports that their senior was doing all right, the thinking went. Instead, the opposite happened. Mahoney cited the example of a man who called his elderly father for 15 minutes every day during his lunch hour. The son used the time to ask his father if he had eaten, bathed, and taken his medicine. The father said, “Who wants their son calling up every day nagging?” Once the monitors were in place, the son could see that his father had no problems, and began to use his phone calls to discuss interesting topics, like the grandson’s baseball games. “The calls became more enjoyable,” Mahoney said. In addition, the older adults in her studies liked having the technology in their homes. “I’ve seen this over and over again. People love to try something contemporary. They talk about it in senior housing. Instead of isolating them, it can give them new ways of engagement.”

Help or Hal? Smart Homes to Ease Elder Care

Science fiction often portrays a future where intelligent robots take over menial tasks and make people’s lives easier. In yet another example of life imitating art, many researchers are studying artificial intelligence as a means to improve in-home care for impaired elders and lessen the burden on their caregivers. Several groups are designing interactive talking devices or crude robots to guide cognitively impaired people through simple household tasks. Such machines are still in a primitive stage, nowhere near the level of sophistication of fictional movie androids. Even so, they may conjure up uneasy feelings in people accustomed to Hollywood portrayals of treacherous computers such as Hal 9000, the artificial villain in 2001: A Space Odyssey. It remains to be seen how comfortable people will be allowing robots to help out with an elderly loved one.

For their part, researchers worry about making the machines intelligent and flexible enough to adapt to the vast range of real-world, hard-to-predict situations they may confront in eldercare. As anyone who has ever argued with a computer knows, machines can be frustratingly limited in their responses. Due to these challenges, the development cycle for one piece of technology can take up to 10 years. With many interactive devices in the pipeline, however, researchers predict we will see some on the market within a few years.

One such researcher is Alex Mihailidis at the University of Toronto, Ontario, Canada. Mihailidis develops “intelligent homes” that adapt to the habits of their occupants and notice when they need help. His work at the Intelligent Assistive Technology and Systems Lab takes the idea of home monitoring systems a step further, by adding a computer brain that can interact with people. One project, called “The COACH” (Cognitive Orthosis for Assisting with aCtivities in the Home), uses interactive software to prompt adults with Alzheimer’s disease to complete simple tasks, such as washing their hands or brushing their teeth. The COACH’s hardware consists of a small webcam and an LCD screen installed on the wall. If the COACH sees that a person is struggling to wash her hands properly, for example, leaving out steps or becoming confused, the COACH either prompts the person verbally, using a recorded human voice, or shows a picture of what she needs to do next.

Washroom with COACH artificial intelligence system.
Image courtesy of Alex Mihailidis and IATSL, University of Toronto

Might people find prompting from a robot irritating? Mihailidis has seen no evidence of that so far. In early trials with people who have moderate to severe AD, most patients did not even realize they were interacting with a computer. “They tend to think their caregiver is outside the washroom giving them instructions,” Mihailidis said. “The key thing is the use of artificial intelligence, so the system can learn about the person and adjust the prompts to those that work best.” Mihailidis has conducted three sets of trials in the lab that showed the COACH improved the ability of cognitively impaired adults to wash their hands. The COACH was well received by patients and their caregivers, Mihailidis claims. In the next trial, he will install the system into the homes of participants to see how it performs in real life. Mihailidis estimated that some version of this technology might become commercially available within three years.

Being confined to a particular room limits the COACH. To expand "his" range, Mihailidis and colleagues installed "him" (or "her") on a small mobile robot; the LCD screen forms the robot's head. In a pilot study of five people with AD, the robot was again able to guide them through tasks such as washing hands and making tea. "We found positive results with respect to people's ability to follow the prompts and to accept the robot," Mihailidis said. Patients reported that they interacted with the robot the same way they would with a person, and said they liked having it follow them around the house. "Quite a few of the caregivers said they wished they had something like this in their homes right now to help out," Mihailidis added.

One challenge with this technology is keeping the price low. "We are trying to develop everything almost as a consumer product," Mihailidis said. A caregiver should be able to buy the machine from a local electronics store, bring it home, and turn it on, and the device should operate without further effort required on the part of the users.

Will robots really make good caregivers for the cognitively impaired? Hollywood has already playfully imagined complications that might occur. The 2012 independent movie *Robot and Frank* centered on Frank, an older man with mild cognitive impairment whose children buy him a robot helper. Unfortunately, Frank is a retired cat burglar who co-opts his robot into helping him plan a new heist, which the robot allows because the excitement and challenge of planning the escapade stimulates Frank's mental skills. Though real-life robot helpers are unlikely to help plan larceny, machines may not be able to adapt to all the situations that a cognitively impaired person might get into. Most researchers foresee such machines operating under the supervision of caregivers, not replacing them. Mihailidis noted that robots need to be self-aware enough to notice when their efforts are not helping and summon human caregivers.

The ability of computer brains to adapt and react intrigues researchers other than Mihailidis. Diane Mahoney at MGH Institute of Health Professions, Boston, Massachusetts, for one, is developing computer software to help impaired adults dress themselves. Mahoney picked this task because, in focus groups, caregivers identified helping with dressing as their most pressing daily concern for loved ones with early to moderate AD. At this stage of the disease, people have the physical ability to dress themselves, but they mix up the sequence, putting underwear above trousers or wool sweaters under shirts. Or they lose focus midway through. Caregivers often spend 45 minutes per day directing and cueing elderly parents through the process. This can cause tension and exhaust the caregiver, Mahoney said.

In collaboration with Winslow Burleson at Arizona State University, Tempe, Mahoney is building a prototype system that can be installed on a dresser or chest of drawers. An iPad sits on top of the dresser to provide visual feedback, iPods give verbal cues, and contact sensors record when drawers are opened or closed. The software is "context-aware" and adaptive, Mahoney said. This means that when the system detects a senior having a problem dressing, it will provide either verbal cues such as, "Open the top drawer. Take out a shirt," or visual cues, such as a picture of a shirt. In addition, a wristband worn by people with AD senses their emotional state by changes in galvanic skin resistance, which measures physiological arousal. If the wristband detects that the senior is becoming agitated, the system will change its cues or play calming music, and if that does not work, will summon the caregiver to intervene. If the person with AD has a good day and gets dressed without a hitch, the system stays silent.

This last feature is important. “Caregivers want to embrace those moments of lucidity, not stifle them,” Mahoney said. People in the focus groups stressed that this sort of technology would empower their relatives to care for themselves. “At a stage when [people with AD] are losing so much, it gives them an acceptable crutch,” Mahoney said.

The system aims to reduce stress on the caregiver. In previous research, Mahoney saw that, “If we can give a caregiver a half-hour’s break and use technology for a safe, distracting activity, that helps reduce the perceived burden. Caregivers are enthusiastic about trying this, because their job is so demanding. Any new tool is appreciated.”

Across the Atlantic in Dublin, Ireland, researchers at the Technology Research for Independent Living (TRIL) Centre are also looking for ways to alleviate caregiver stress. They are developing tablet-based software applications that provide educational material and a peer support network for relatives of AD patients. In addition, caregivers could use the system to report patient health data to providers. “It’s a communications and support platform,” said academic director Brian Caulfield. “We are not just asking the caregivers for information on how patients are doing, but also how they are doing. That will influence the type of support educational material that is delivered to the caregivers.” Principal investigator Brian Lawlor at Trinity College Dublin is currently conducting user evaluations on the prototype.

Other groups are thinking bigger than home or portable app design. Intel Corporation, Santa Clara, California, is collaborating with the Chinese government and industry on an initiative called “Age-Friendly Cities” (see Intel blog). This means creating an urban and rural infrastructure, supported by an integrated information technology network, that makes services more accessible to older adults, communications manager Charing Riolo told Alzforum. For example, a person’s cell phone might tell her where the city bus is on its route, and when she should leave her house in order to catch it, Riolo said. “It’s about making everything seamless and comfortable so that an older person can stay active.” The communications network would facilitate remote patient monitoring, social networking, and caregiver support, with the ultimate goal of keeping people in their homes and reducing institutionalization.

Such a future city may sound utopian to some, but to others it will likely conjure the “Big Brother” image of intrusive surveillance. Designers have to find ways to allay such fears and build in personal control before such far-reaching technology will be accepted.

Behavioral and Cognitive Interventions

Could playing a computer game or video chatting with friends help you ward off Alzheimer's disease? This sounds like a tall order, though epidemiological evidence consistently links high lifetime levels of cognitive and social stimulation to a lower risk of getting AD (see, e.g., ARF related news story; ARF news story; ARF news story; and ARF news story). Such lifestyle findings have made researchers wonder if mental training or social activity in late life could protect the brain. The boom in computer and personal technology use makes this approach appealing, as technology provides tools for reaching homebound older adults. Such interventions have the advantage of being safe and relatively cheap compared to most pharmacological agents. But do they work? Studies of specific approaches have often come up short (see, e.g., ARF related news story; ARF news story), leaving unanswered the question of whether late-life mental stimulation can slow cognitive decline.

"There has never been a really good test of cognitive remediation," John Harrison at Metis Cognition, Warminster, Wiltshire, U.K., told Alzforum. Still, he believes the strategy could work. "We have a sense we can still help patients in the very early stages by tutoring them on cognitive tasks, in the hope that it will preserve cognition for a little longer."

Although many groups have developed brain-training software and cognitive interventions, often these approaches do not get validated in clinical trials due to the high costs of testing. For example, the European-based HERMES project, an EU-funded collaboration between organizations in six countries that ran from 2008 to 2011, developed a technology to assist older adults with daily life and support cognitive functions. The hope was that this would allow people to maintain their independence longer. Specifically, the system helps people with mild memory problems remember past events and keep track of future plans. A mobile phone and a home computer with two webcams allow users to record portions of their day and later play them back to refresh their memories of events. A calendar and personal data assistant (PDA) help seniors remember upcoming events. The computer also contains several cognitive games: mazes, jigsaw puzzles, and a program that trains users how to remember people's names. Over three years, the HERMES team built and refined a prototype using input from older adults who were either cognitively healthy or had age-related memory loss. They also tested the system in a handful of user homes.

"The elderly [participants] were able to learn how to use the system, and were happy with it," said Mari Feli Gonzalez at INGEMA Foundation, Spain, who worked on the project. She added that the team learned about designing interfaces for older adults, as well as the difficulties involved in taking a computer system from the lab to a real-world home environment. In the home, the system sometimes broke down due to the users' unfamiliarity with technology, which led them to push the wrong buttons and freeze the programs. Gonzalez noted that the system would need to be made more robust for home use. However, the HERMES project has ended and the team has no current plans to market the technology, Gonzalez said. The project also had insufficient funding to test whether using the system long term prevented cognitive decline.

Some commercial brain-training companies have raised millions of dollars to test cognitive interventions. One example is Lumosity, a seven-year-old company based in San Francisco, California, that provides online cognitive training through a suite of games and boasts 30 million users worldwide. Lumosity conducts studies based on its enormous dataset of users, who agree to provide anonymous demographic information and game play data to the company. The company has presented findings from its database at neuroscience conferences. Lumosity was co-founded by a Stanford neuroscience PhD candidate and consults a scientific advisory board to help develop its interventions. In its Human Cognition Project, Lumosity partners with more than 1,500 academic researchers worldwide to test the efficacy of its games in various populations, said program manager Elizabeth Ricker. Researchers gain access to Lumosity's cognitive tools, its assessments, and its database on human cognitive performance. In order to maintain objectivity, the company does not currently fund researchers, Ricker added.

However, to date, few published studies have looked at whether Lumosity's training programs slow cognitive decline in older adults. One study on people with mild cognitive impairment, led by Maurice Finn at the University of New South Wales, Australia, found that 16 participants who completed 30 cognitive training sessions developed better visual sustained attention compared to a control group. The intervention did not improve everyday memory abilities or mood, Finn reported (see Finn and McDonald, 2011). Lumosity is currently pursuing MCI and aging studies with independent researchers in four different countries. One such ongoing clinical trial at University College London, U.K., tests a combination of Lumosity cognitive training with physical and social interventions in 128 people with MCI to see if the treatment delays dementia onset.

The London-based brain-training company My-Cog is also starting clinical trials of its intervention. Similar to the HERMES project, My-Cog has developed a three-pronged approach to keeping older people cognitively active and living at home. An online virtual assistant helps people remember appointments and tasks, while a computerized "memory box" will include photos of important people and places in the user's life, as well as linking the participant to an online community of close friends and relatives who share those memories, said CEO Claire Mitchell. Cognitive games make up the third aspect of the intervention. To keep the games interesting enough to hold people's attention over months of play, the company has partnered with gaming companies to develop a game with a full graphic interface in which participants control an avatar and have to complete various tasks. Clinicians, neurologists, and psychologists helped design the tasks to exercise working memory, executive function, and attention, Mitchell said. Users will take cognitive pre-tests that will assign a gaming "prescription," as well as occasional ongoing tests to track people's status and flag problems. (See also Wall Street Journal blog, in which Harrison, who consults for the company, describes a prototype of the game.)

A 12-week pilot trial of the game starts in January 2013. It will include 450 junior high and high school students (300 who will play the game and 150 controls), as well as 60 people with AD and 20 people with Parkinson's disease. Hugo de Waal at Norfolk and Waveney Mental Health Trust, Norwich, U.K., and Bastiaan Bloem at Radboud University Nijmegen Medical Centre, the Netherlands, lead the trial. This pilot will test whether the system is easy to use and keeps people engaged, Mitchell said. A full Phase 1 trial of 300 people with AD and PD is currently recruiting for a planned start in summer 2013.

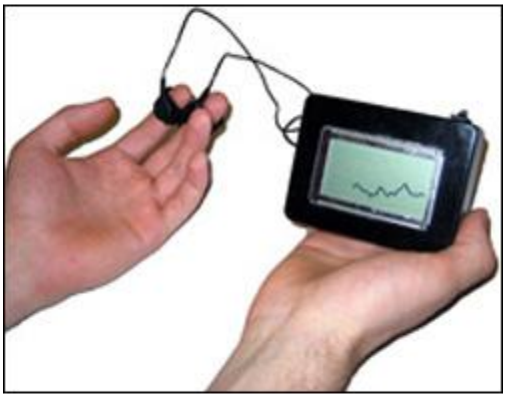
While many groups have tried to devise cognitive interventions, few studies have examined the cognitive effect of promoting social engagement in the elderly with technology. One such project is the pilot video chatting study run by Hiroko Dodge at the Oregon Center for Aging and Technology (ORCATECH) in Portland. Dodge plans to enroll 100 participants with normal cognition or mild memory problems into a clinical trial. All participants will take the CAMCI and CogState computerized cognitive tests, as well as standard neuropsychological exams, before and after the study. Half the participants will receive a social intervention every day for six weeks, in the form of a 30-minute video phone call from a researcher. The calls will use a standardized protocol that includes quizzes, picture descriptions, and a chat about what the participant did the day before.

Dodge is currently recruiting participants, and expects to begin collecting data next year. She noted that one reason to try social stimulation instead of cognitive is because computer games can require a high level of cognitive ability. "We thought conversation, which anyone can do, might be more accepted by people with cognitive decline or impairment," Dodge said. People with mild cognitive impairment tend to dread cognitive testing, in part because it is difficult and shows them their impairment. If Dodge sees improved scores on cognitive post-tests in this trial, she will test a larger group of people to investigate whether cognitively normal people or those with mild cognitive impairment benefit more from the intervention.

Since epidemiological evidence suggests that cognitive, social, and physical activity all slow cognitive decline and lower the risk for AD, would combining these three types of intervention give more bang for the buck? Another study at ORCATECH addresses that question. Led by Holly Jimison, the study follows 33 cognitively healthy adults, average age 85, who live at home. "We focus on building cognitive reserve and delaying decline," Jimison said. Participants play a range of computer games that allow the researchers to monitor memory, attention, planning, and verbal fluency over time. The researchers enrolled family members who live far away and encouraged them to make Skype video calls to their elders. Often, the older adults in the study would log in to the system and not see a family member available, but would find other people in the study online. Participants began chatting with each other and formed close friendships, Jimison said. "We lean now toward including participants as part of their own social network." In addition, the study monitors participants' physical activity, sleep, and general health. A "health coach" receives the data and works with the participant on behavioral interventions, for example, setting up an exercise program, suggesting ways to improve sleep, and teaching relaxation techniques.

Jimison's current goal is to show that the system is feasible. "We are first trying to show that we can keep people engaged and facilitate a coach in reaching a large number of clients. We want to make this scalable and cost effective." Then she wants to test the system in a large clinical trial and adapt it for different cultural groups. Her ultimate goal is to slow cognitive and physical decline. "If we can delay symptoms, we can improve quality of life and influence cost and caregiver burden," Jimison said.

Many older adults lose their independence due to a fall or accident. A broken hip or ankle can land a previously self-sufficient person in a nursing home, often for life. A study at the Technology Research for Independent Living (TRIL) Centre, based in Dublin, Ireland, looks at how technology might reduce this risk. Research suggests that elderly people are less mentally alert at certain times of the day, leaving them prone to accidents and falls, noted academic director Brian Caulfield. Therefore, participants in the "Training for Focused Living" project, led by Ian Robertson at Trinity College Dublin, receive in the mail an alertness training packet that consists of a booklet, a CD, and a biofeedback device. Over four weeks, participants read the booklet and learn specific exercises to sharpen their focus. For example, people will pick a "prime word" that helps them visualize something that gets them excited, such as a sporting event. Then participants use the biofeedback device to see if that increased their physiological arousal. The device consists of two finger-cuff electrodes that measure galvanic skin resistance as a surrogate measure of brain electrical activity. Users see visual feedback on an LCD screen embedded in a cushion they place in their lap. (Caulfield noted that during the design process, participants would typically place the screen on a lap cushion for viewing, so the researchers incorporated the device into such a cushion.)



Measuring physiologic arousal with finger-cuff biofeedback device. © *TRIL Centre*

Once participants have learned to boost their alertness, they can apply the technique during low points in the day. For example, if a person has just eaten lunch and feels a bit sleepy, he or she can perform the exercise before standing up to walk to the bathroom. The researchers expect that being more alert will reduce a person's risk of falls. As a side benefit, the training also seems to help with cognition. "We have done a prospective trial of this training program and found that it had positive effects on executive order functions," Caulfield said, citing improvements on measures of category fluency and the Vigilant Auditory Attention Test. "Essentially, we are trying to tap into the cognitive reserve a person might have." Robertson would like to scale up the technology and make it widely available, Caulfield noted.

Time will tell whether any of these strategies pan out. Even so, in the absence of effective pharmaceutical agents to treat AD, the field of tech-driven cognitive stimulation is likely to burgeon, Harrison said. Computers and personal electronics are also changing how scientists diagnose AD, and how people monitor and care for loved ones with dementia, as described in the earlier installments of this series. Altogether, technology appears poised to infiltrate the way we age.