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Unobtrusive measurement of daily computer use to detect mild cognitive impairment

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Abstract

Background: Mild disturbances of higher order activities of daily living are present in people diagnosed with mild cognitive impairment (MCI). These deficits may be difficult to detect among those still living independently. Unobtrusive continuous assessment of a complex activity such as home computer use may detect mild functional changes and identify MCI. We sought to determine whether long-term changes in remotely monitored computer use differ in persons with MCI in comparison with cognitively intact volunteers.

Methods: Participants enrolled in a longitudinal cohort study of unobtrusive in-home technologies to detect cognitive and motor decline in independently living seniors were assessed for computer use (number of days with use, mean daily use, and coefficient of variation of use) measured by remotely monitoring computer session start and end times.

Results: More than 230,000 computer sessions from 113 computer users (mean age, 85 years; 38 with MCI) were acquired during a mean of 36 months. In mixed-effects models, there was no difference in computer use at baseline between MCI and intact participants controlling for age, sex, education, race, and computer experience. However, over time, between MCI and intact participants, there was a significant decrease in number of days with use ($P = .01$), mean daily use ($\sim$1% greater decrease/month; $P = .009$), and an increase in day-to-day use variability ($P = .002$).

Conclusions: Computer use change can be monitored unobtrusively and indicates individuals with MCI. With 79% of those 55 to 64 years old now online, this may be an ecologically valid and efficient approach to track subtle, clinically meaningful change with aging.

Keywords: Mild cognitive impairment; Assessment of cognitive disorders/dementia; Cohort studies; Activities of daily living; Computer use

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1. Introduction

The use of technology and, in particular, computer-based devices continues to proliferate in everyday life. This phenomenon, although commonly thought to be characteristic of younger populations, is also seen among our aging population. Almost 80% of adults age 55 to 64 years who represent the next generation of seniors are online in the United States [1]. This generation has among the most rapid rates of adoption of smartphone [2] and social media technologies [1]. They are perceived as driving the digital fitness industry with their interest in playing online games and participating in brain fitness programs to stave off cognitive decline. The shift to adoption of computer technologies may also come of necessity. For example, last year the Social Security Administration announced that they would no long mail annual statements, but only post them online. The increasing use and incorporation of these technologies into the flow of the day has, in effect, created a new higher order or instrumental activity of daily living (IADL) that is increasingly important to the senior community—achieving, in many cases, the status of a near necessity for contemporary life.

In the context of considering computer activity as an emerging IADL, it is important to consider computer use itself as a complex task taxing multiple cognitive domains (attention, working memory, episodic memory, executive function, and so on). As a complex task, computer use is likely to be sensitive to cognitive change and thus might be a bellwether of brain health, aging cognition, or the onset of mild cognitive impairment (MCI). These cognitive concerns that may be affected by computer use competency are especially important for the growing community of adults age 55 to 64 years.

People with MCI are, by definition, not demented. However, definitions of MCI are not specific with regard to criteria for determining the functional status of the person with MCI, leaving uncertainty regarding the degree of function that qualifies as having "essentially normal functional activities" [3]. This is, at least in part, a reflection of the difficulty of assessing clinically the gradual and subtle affect that mildly degraded cognition may have on day-to-day function. People with MCI may continue to work and engage independently in community and household affairs, and to operate electronic devices. Nevertheless, a large body of evidence suggests that mild cognitive decline is accompanied by decrements in the ability to perform complex IADLs such as medication taking, telephone use, and meal preparation, even years before frank dementia or symptomatic MCI is evident [4–16]. Speaking to the subtlety of this functional disturbance, several studies have shown that self-report may not be adequate to detect this change. Thus, direct functional performance tasks simulating IADLs and performed in front of a clinician or examiner may be more sensitive to identifying IADL deficits in MCI [12,14,15]. However, these direct assessments add to the time of testing, and although they involve direct manipulation of common objects to assess function, some of these items may not be a part of activities in which the person engages routinely, such as writing a check or mailing a letter. The assessment is not ecologically valid and does not reflect how the person performs in his or her usual daily environment over time.

An alternative approach to the assessment of daily function is to bring the assessment into the home through remote monitoring using sensors placed strategically in the home environment to track daily function continuously in real time. Thus, a home network of motion sensors can provide information about functional activity in particular locations of a residence, while specific instrumentation of devices used commonly, such as the telephone, medication caddies, or a personal computer, provides information about the interaction with these devices. We present results from a longitudinal cohort study—Intelligent Systems for Assessing Aging Change, or ISAAC—that compares older people with MCI with noncognitively impaired individuals living independently by assessing the specific higher order activity of daily living of computer use. To study computer use in the current aging population, in which computer use is not as prevalent as in the next generations, we initially trained each participant to a level of computer literacy defined as being able to send and receive e-mail independently. We hypothesized that, over time, those with MCI would spend fewer days and less time on the computer, and that their day-to-day variability in use would increase.

2. Methods

2.1. Study participants

The research protocol was approved by the Oregon Health and Science University Institutional Review Board (OHSU IRB no. 2353). All participants provided written informed consent. Participants were recruited from the Portland, Oregon, metropolitan area through advertisement and presentations at local retirement communities as part of the ISAAC longitudinal cohort study. Details of the study protocol for ISAAC have been published elsewhere [17]. Briefly, entry criteria for the study included being a man or woman age 70 or older, living independently (living with a companion or spouse was allowed, but not as caregiver), not demented (Mini-Mental State Examination [MMSE [18]] score >24; Clinical Dementia Rating [19] scale score ≤ 0.5), and in average health for age. Medical illnesses that would limit physical participation (e.g., wheelchair bound) or likely lead to untimely death (such as certain cancers) were exclusions. A total of 265 participants were enrolled (beginning in 2007). The participants lived in a variety of settings—from apartments in organized retirement communities to freestanding single-family homes. We present data for 113 participants living alone or who were the only computer user at home.