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# Computer mouse movement patterns: A potential marker of mild cognitive impairment

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**Abstract**

**Introduction:** Subtle changes in cognitively demanding activities occur in mild cognitive impairment (MCI) but are difficult to assess with conventional methods. In an exploratory study, we examined whether patterns of computer mouse movements obtained from routine home computer use discriminated between older adults with and without MCI.

**Methods:** Participants were 42 cognitively intact and 20 older adults with MCI enrolled in a longitudinal study of in-home monitoring technologies. Mouse pointer movement variables were computed during one week of routine home computer use using algorithms that identified and characterized mouse movements within each computer use session.

**Results:** MCI was associated with making significantly fewer total mouse moves ($P < .01$) and making mouse movements that were more variable, less efficient, and with longer pauses between movements ($P < .05$). Mouse movement measures were significantly associated with several cognitive domains ($P$ values $<.01–.05$).

**Discussion:** Remotely monitored computer mouse movement patterns are a potential early marker of real-world cognitive changes in MCI.



*Keywords:* Everyday functioning; Cognitive assessment; Technology; Ecological validity; Instrumental activities of daily living; Aging; Computer use; Early detection of cognitive decline; Mild cognitive impairment; Functional assessment; Remote monitoring

## 1. Introduction

Alzheimer's disease (AD) is a leading cause of death in America [1], and currently there is no prevention or cure. An important goal is to identify presymptomatic changes in healthy community-dwelling individuals that are predictive of future cognitive decline and transition to mild cognitive impairment (MCI) and AD. Reliable detection and tracking of early cognitive changes will be critical for deriving maximum benefits from currently available treatments, measuring response to preventative and symptomatic treatments in clinical trials, and facilitating cost-effective, large scale community cognitive screening [2–4].

To identify meaningful cognitive changes in community-dwelling older adults as early as possible, practical assessment tools are needed that are cost-effective, noninvasive, and nontaxing. Assessing β-amyloid and tau biomarkers is costly and difficult to apply widely among presymptomatic older adults, and reduction of β-amyloid

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in the brain has not yet demonstrated clear clinical benefits [5]. Conventional standardized cognitive tests have been shown to be strong early predictors of transition to future dementia [6–10]. However, conventional cognitive tests are typically administered infrequently and are not ideally suited to tracking intraindividual cognitive change. These tests are often used to make inferences about an individual's ability to function in the real world, and yet due to fundamental differences between the testing (clinic) setting and one's real-world environment, the generalizability or ecological validity of these tests has been questioned [11].

Measuring daily function in aging, MCI, and dementia populations has its own unique challenges. For example, there is large individual variability in what activities are typically performed by older adults and how they are carried out (e.g., medication management, finances, appointments, computer use, shopping, and household tasks). In addition, functional assessment instruments that do not discriminate with fine precision across the normal to mildly impaired range of functional ability can lead to ceiling effects for people with very early MCI [2]. There are data to indicate, for example, that subtle but consistent changes signaling less efficient or effective performance in carrying out everyday activities occur in early MCI and are directly associated with cognitive changes [12–14]. These very early and gradual changes may be important signals of incipient neurodegenerative disease but they are not well captured by available functional assessment measures that are largely based on self- or informant-report. There is a need for reliable and valid instruments that are able to measure subtle cognitive changes as they develop in presymptomatic and MCI older adults' daily lives with greater individualization and precision [15].

Recent advances in wireless technology, pervasive computing, and multidomain analytics have made it possible to unobtrusively measure cognitive activity in an individual's own environment, every time a person interacts with common devices such as a computer, automobile, telephone, or pillbox [16–19]. Continuous (e.g., daily, weekly, monthly) assessment of individuals' day-to-day functioning makes it possible to more accurately track and measure relevant intraindividual changes in daily functioning that emerge earlier than with conventional yearly cognitive or functional assessment methods alone. Applied to clinical trials, frequently measured unobtrusive activity data would require smaller sample sizes to obtain sufficient power for detecting meaningful change, facilitating faster and more productive trials and drug development [20]. Another advantage of this new assessment paradigm is that monitoring technology is discretely embedded within commonly used devices and requires no extra effort or action by the individual outside of their normal routine [21]. Thus, the information obtained is representative of individuals' actual daily functioning under normal conditions. Given that the fastest growing segment of the population adopting mobile and computer technology are those older than age 65, it is now feasible and relevant to monitor cognitive functioning of older adults through computer use.

The present study is part of a larger, longitudinal cohort study. In the study reported here, we were interested in learning whether ambiently assessed computer mouse movement patterns taken from 1 week of routine home computer use would discriminate between older adults with and without MCI. Owing to their mild cognitive deficits and relative difficulty managing complex everyday technology including computer use [16,22], we hypothesized that the mouse movement patterns of older adults with MCI would be less efficient compared with those of the cognitively intact group. In addition, we examined relationships between the mouse movement measures and traditional cognitive assessment measures in the total sample, regardless of diagnosis, to provide preliminary evidence of convergent validity of these new measures across the spectrum from normal cognition to MCI.

## 2. Methods

### 2.1. Study design

All participants provided written informed consent and were already enrolled in one of two ongoing studies of in-home monitoring: the ORCATECH Life Laboratory study and the Intelligent Systems for Assessing Aging Changes (ISAAC) study (www.orcatech.org). Participants were recruited from the Portland, OR, USA, metropolitan area through advertisement and presentations at local retirement communities. The study protocols were approved by the Oregon Health & Science University Institutional Review Board (Life Laboratory IRB #2765; ISAAC IRB #2353). Both studies use the same in-home sensor technology and computers to detect early behavioral and cognitive changes that occur with aging. Additional details of the sensor systems and study protocols have been published elsewhere [21,23]. Inclusion criteria were $\geq$60 years for the Living Laboratory study and $\geq$80 years for the ISAAC study, living independently (living with a companion or spouse was allowed, but not as caregiver), not demented as evidenced by a mini-mental state examination (MMSE) [24] score $>$24, a clinical dementia rating (CDR) [25] scale score $\leq$0.5, and in average health for age. Exclusionary criteria included chronic or poorly controlled medical illnesses. 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 free-standing single-family homes.

### 2.2. Study participants

There were 125 active Life Laboratory/ISAAC participants during 2011–2012. Of this group, there were 83 who