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# Attitudes Toward Computers Moderate the Effect of Computerized Cognitive Trainings in Oldest-Old Senior Living Center Residents

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ABSTRACT

***Background and Objectives:*** *Computerized cognitive interventions (CCIs) have been increasingly implemented among older adults with mild cognitive impairment (MCI). However, older individuals' attitudes toward technology may limit CCI engagement. This exploratory-developmental study examined whether a "multi-functional interactive computer system" (MICS), which provides pleasurable activities via computer, would improve attitudes toward computers and in turn increase the efficacy of a subsequent CCI.* ***Research Design and Methods:*** *A phase one double-blind trial randomized 49 seniors with MCI to a MICS + CCI condition or a CCI-only condition. Attitudes toward technology use was assessed using The Attitudes Toward Computers Questionnaire (ATCQ), and cognition was assessed using episodic memory and executive function composite scores at baseline, the ends of MICS and CCI phases, and 3-month follow-up.* ***Results:*** *The MICS + CCI group did not show significantly greater improvement in cognition than the CCI only group. Secondary analyses indicated that improvement in executive function from baseline occurred in both groups. Participants who did show improved attitudes toward computers, whether through MICS or simply computer exposure itself, showed improvement in executive function.* ***Discussion and***

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***Implication:*** *Participants in the MICS + CCI group used MICS less than expected. A more structured and supervised approach may be needed to facilitate MICS exposure. Improved attitudes toward computers regardless of MICS exposure may benefit candidates for CCI.* (Am J Geriatr Psychiatry 2020; ■■:■■−■■)

## INTRODUCTION

Computerized cognitive interventions (CCIs) have been increasingly widely implemented among older adults with mild cognitive impairment (MCI).[1] Compared to traditional cognitive interventions, CCIs offer additional benefits including matching training content and difficulty with individual performance, visual appeal and variety, transportability, and scalability.[1] Yet the efficacy of CCIs in maintaining or improving older adults' cognitive and functional health has been modest in an overall sense, and highly variable across individuals and studies. For example, in a recently completed randomized controlled trial (RCT) in older adults with MCI, we found similar to others[2,3] that vision-based speed of processing training, a widely-applied CCI, was superior to an active control in improving both trained (i.e., attention and processing speed) and/or untrained (i.e., working memory and instrumental activities of daily living) outcomes.[4,5] However, considerable variability appeared around the main effects for the intervention. This variability was not explained by typical demographic or clinical factors, leading us to suspect other processes at play in older adults' treatment response.[6]

Intriguingly, older individuals' attitudes toward technology may help explain the variety in vision-based speed of processing training effects.[4] Negative attitudes about computers—defined broadly by affective, cognitive, and behavioral-motivational components, may interfere with engagement with, and thus the efficacy of CCIs.[6] Compared to their middle aged or younger counterparts, older adults' views of computers are distinguished by lack of confidence or comfort, negative beliefs, and increased anxiety.[7−9] Not surprisingly, such attitudes toward computers are an important predictor of actual engagement with computers in old age: comfort with and interest in using computers promotes the use of computers, while lack of self-efficacy and increased anxiety result in less use of computers.[8,10−12] Moreover, attitudes toward computer use may largely explain the relationship between computer use and cognitive function in old age.[13] That is, those who view computers favorably tend to use them more frequently, which in turn predicts better cognitive function.[13] Negative attitudes toward computers may be even more common in older adults with MCI.[14] Fortunately, evidence suggests that these negative attitudes can be ameliorated. Direct contact with computers, including computer-based activities, generate or promote positive attitudes[15−17] and can occur rapidly (two weeks in one case,[18] less than a week in another[7]).

Person-centered care—that is, integrating individuals' preferences throughout the process of intervention−−has improved intervention engagement among older persons, including those with MCI.[19] A recent intervention predicated on this person-centered approach is called "multi-functional interactive computer systems" (MICS). MICS involves a database of individualized computer-led leisure activities. Theories of attitude change and motivation[20,21] suggests that MICS may act as a "mastery experience," pairing positive affect with successful goal-attainment in computer use, thereby reducing negative attitudes and increasing computer self-efficacy.

In this phase 1 randomized controlled trial, we aimed to assess the effect of an intervention with initial period of MICS, followed by a standard CCI, on attitudes toward computers. We then attempted to determine whether older individuals exposed to MICS benefited more from a standard CCI then those who were not. We specifically focused on older adults with MCI in senior independent living facilities, since MCI persons in these settings are among oldest-old group, at higher risk for developing dementia,[22,23] poorer quality of life, loss of independence, and higher rates of transition to a nursing home.[22,24] We hypothesized that MICS, by delivering computer-led leisure activities in a person-centered manner, would improve older adults' attitudes toward computers. We also hypothesized that improvement in attitudes toward computer would lead to improved cognitive outcomes.

## METHODS

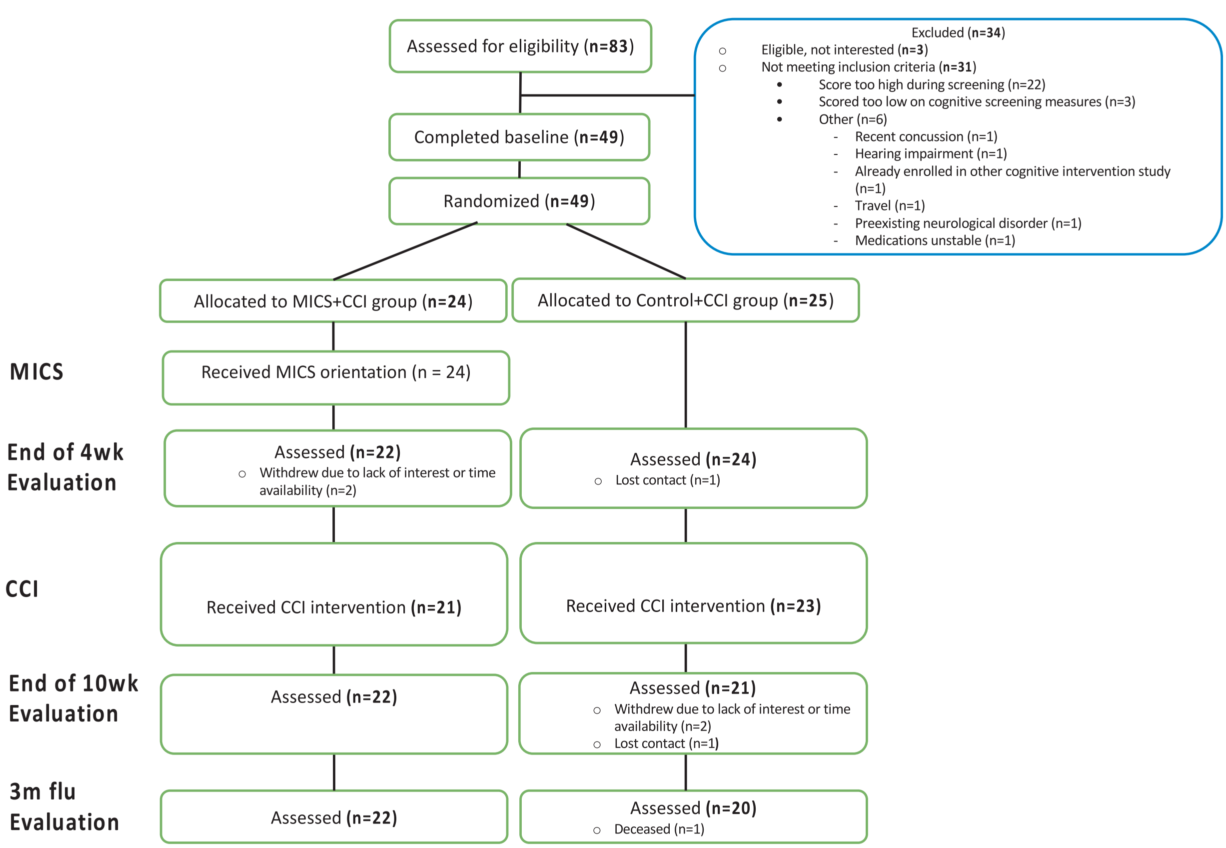
### Design

A double-blinded, multisite RCT of MICS+CCI, versus control + CCI was involved. The CONSORT diagram is presented in Figure 1. The study has been registered at clinicaltrial.gov as NCT03292705.

### Participants

Participants were recruited from five local senior independence living centers, which are all licensed by New York State and similar in resident age, gender, and costs, as well as continuum of care. Each facility provides case management, three meals and snacks (approved by a registered dietician), housekeeping services, social and recreational activities, religious services, and 24 hour/day monitoring, supervision and assistance with scheduled and unscheduled needs (grooming, emergency care, etc.). Staff at the facilities briefly introduced the study to the residents. Residents who were interested in screening and learning more about study signed up for the registry. Screening and consent were conducted at facilities by our research team independently to avoid any potential perceptions of coercion by facility staff. Since the diagnostic criteria for MCI has been used inconsistently across residents in these centers, we conducted cognitive screening following the diagnosis of "mild cognitive impairment due to Alzheimer's disease" of the NIA and Alzheimer's Association workshop criteria[25]: 1) must have subjective cognitive complaint measured; 2) must have memory deficit (Rey's Auditory Verbal Learning Test [RAVLT] ≤6); 3) intact or mild deficits in activities of daily living (Activities of Daily Living-Prevention Instrument [ADL-PI-self] Total Score ≤30, 4) absence of dementia derived from

**FIGURE 1. CONSORT diagram.**



medical records. If on AD medication (i.e., Memantine or cholinesterase inhibitors), antidepressant, or anxiolytics, no change of doses in the 3 months prior to recruitment was required. In addition, all participants were age ≥65 years, English-speaking, and had adequate visual acuity for testing. We excluded anyone currently enrolled in another cognitive improvement study, who had poorly controlled major depression (i.e., 15-item Geriatric Depression Scale [GDS] scored >7[26] or other psychopathology identified by staff or medical records), or had an active legal guardian (indicating impaired capacity for decision making). All participants signed an informed consent and the study was approved by University Research Review Board.

### Randomization and Intervention

Randomization was stratified by size of the facility (10 participants randomized to 2 groups in 3 facilities with <80 beds, and 39 randomized to 2 groups in the other 2 facilities with >100 beds). Group assignment was not disclosed until the end of baseline assessment. For MICS+CCI group, MICS was implemented for the first 4 weeks, and CCI for the following 6 weeks. For the control + CCI group, an inert control condition, consisting of nothing outside of the ordinary, was implemented for the first 4 weeks, and CCI for 6 more weeks. Participants were informed that they would receive CCI, and advised to avoid discussing their group assignment with other residents in the same facility.

#### *MICS*

We used the *It's never 2 late* (IN2L, Colorado) system, which is built on a picture-based touch-screen interface on tablet computers[32]. IN2L allows users to explore and participate in entertainment, educational, spiritual, and other recreational activities and content personalized according to their interests and preferences. It provides easy access to the Internet and communication applications, and has hundreds of modules spanning music, travel, trivia, games, and religious and inspirational domains. For instance, if music is among a person's lifelong interests, the IN2L system provides access to multiple music genres through jukebox, karaoke and therapeutic music applications that can be tailored to a particular activity and by individual interest (for instance, a preference for classic jazz). As another example, for someone who likes travel or visiting new places, the interface offers access to Google Earth, guided tours, slide shows, and regional facts and history. We tracked the amount and type of particular usage for each individual in the MICS+CCI group. A pilot study suggested MICS would be used about 5 hours a week, and 5 hours per week for 4 weeks was consistent with the literature emphasizing the importance of daily engagement of stimulating leisure activities as well as the effect of amount of engagement on cognition.[27] The initial MICS "dose" of 4 weeks was also based on prior work on attitude change and computer use[18]. Of note, the five facilities did not already have the IN2L system as part of their provided leisure activities.

#### *CCI*

CCI uses the INSIGHT online program (Posit Science, CA), which includes five training paradigms (Eye for detail, Peripheral challenge, Visual sweep, Double decision, Target tracker) that practice processing speed and attention. This program has been used in prior work.[4] All exercises share visual components and focus on accuracy and fast reaction times. Participants respond either by identifying what object they see or where they see it on the screen. The training will automatically adjust the difficulty of each task based on the participant's performance, ensuring that the participants always operate near their optimal capacity. The training programs will automatically record the percentage of completion of each game and scores. CCI was suggested for four 1-hour sessions per week for 6 weeks, a period prior work has suggested.[22] For both MICS and CCI, we provided orientation. All other sessions were self-administered by participants with a 24/7 hotline and weekday-based in-person visit available for technical support. No adverse effect was associated with the interventions.

### Measures

Separate staff blinded to intervention assignment conducted post-training and follow-up assessments. Assessments were conducted at baseline, the end of 4-week, the end of 10-week, and 3-month follow-up.

**TABLE 1. Baseline Characteristics**

| | Total (N = 49) | MICS + CCI (n = 24) | Control + CCI (n = 25) | t or $\chi^2$, df (p) |
|---|---|---|---|---|
| Age, mean (SD) | 86.39 (5.66) | 86.75 (5.26) | 86.04 (6.10) | 0.44, 47 (.71) |
| Years of education, mean (SD) | 16.56 (2.16) | 16.42 (2.08) | 16.70 (2.27) | −0.45, 47 (0.65) |
| Male, n (%) | 18 (36.7) | 9 (37.5) | 9 (36.0) | 0.01, 1 (0.91) |
| Non-Hispanic White, n (%) | 46 (93.9) | 23 (95.8) | 23 (92.0) | 46 (93.9) |
| MOCA, mean (SD) | 23 (3.00) | 23 (2.43) | 22 (3.39) | 1.44, 47 (0.16) |
| RAVLT number of delayed recall, mean (SD) | 5 (2.68) | 5 (2.60) | 5 (2.78) | −0.63, 47 (0.53) |
| ADL-PI, mean (SD) | 18.94 (3.51) | 18.38 (4.16) | 19.48 (2.74) | −1.10, 47 (0.28) |
| GDS, mean (SD) | 1.45 (1.60) | 1.33 (1.58) | 1.56 (1.64) | −0.49, 47 (0.62) |
| Taking AD medication, n (%) | 0 | 0 | 0 | - |
| Chronic condition index, mean (SD) | 5 (2.65) | 6 (2.98) | 5 (2.20) | 1.55, 47 (0.13) |
| Senior living center bed size < 80, n (%) | 10 (20.4) | 5 (20.8) | 5 (20.0) | 0.01, 1 (0.94) |
| Hours of MICS training | - | 7.30 (7.98) | - | - |
| Hours of CCI training | 13.92 (8.27) | 14.48 (6.75) | 13.40 (9.58) | 0.43, 42 (0.67) |

MOCA: montreal cognitive assessment; RAVLT: Rey's auditory verbal learning test; ADL-PI: activities of daily living-prevention instrument; GDS: 15-item geriatric depression scale; MICS: multifunctional interactive computer systems; CCI: computerized cognitive intervention.

Additional demographic and health history data was collected at baseline (see Table 1).

*Attitudes Toward Computers Questionnaire (ATCQ)*

The ATCQ is one of the most common instruments assessing attitudes related to computer/internet. The ATCQ is a 35-item scale with 5-point Likert response options, assessing 7 dimensions of attitudes toward computers: comfort (feelings of comfort with computers and their use); efficacy (feelings of competence with the computer); gender equality (the belief that computers are important to both men and women); control (the belief that people control computers); interest (the extent to which one is interested in learning about and using computers); dehumanization (the belief that computers are dehumanizing); and utility (the belief that computers are useful). It forms a single mean score, which was our primary outcome. The ATCQ has been used in prior research with elderly samples[25,26] including those MCI persons with good internal consistency and test-retest reliability (both >0.85) and validity.[7,8,28] In the current study, the Cronbach's $\alpha$ for the entire scale was >0.70 across all time points.

*Brief Visuospatial Memory Test (BVMT)-R*

The BVMT-R is a well-validated battery of long-term visual memory in terms of learning and delayed recall.[29] These measures are commonly used and reliable and valid for patients with MCI,[30] and used in our previous work. A composite score averaging T-scores of learning and delayed recall was used to reflect episodic memory.

*EXAMINER*

Examiner was developed by the National Institute of Neurological Disorders, and is a computerized test designed for clinical trials measuring several executive function domains that are used to develop a composite score. The score is based on tasks related to verbal fluency, cognitive control and working memory, measuring executive function. The test has been validated to detect cognitive function related to the prefrontal cortex.[31] Both BVMT-R and EXAMINER have assessment packages that are slightly different at each assessment point to avoid practice effects.

**Data Analysis**

Analysis was conducted using SPSS 24.0. We compared baseline characteristics to determine equivalency using independent t tests for continuous variables and $\chi^2$ tests for categorical variables. Primary analyses examined whether the two groups differed on cognitive improvement at follow-up. Intention-to-treat analysis was conducted based on the initial "Group" assignment with at least one follow-up assessment. To determine the between-group effect on outcomes, we fit a Generalized Estimating Equation (GEE) model with an AR(1) working correlation matrix: $y = \beta 0 + \beta 1\ Time + \beta 2\ Group + \beta 3$

**TABLE 2. Group[a] byTime[b] interaction Effect on Outcomes**

| | Intervention Effect at the End of 4 Week (MICS + CCI n = 22; Control + CCI: n = 24) | | Intervention Effect Across All Time Points (MICS+CCI n = 22; Control + CCI: n = 20) | |
|---|---|---|---|---|
| | B (SE) | Wald's $\chi^2$ (p) | B (SE) | Wald's $\chi^2$ (p) |
| ATCQ | −0.01 (0.05) | 0.03 (.86) | −0.02 (0.02) | 1.04 (.31) |
| Episodic memory | −0.74 (3.23) | 0.05 (.82) | −0.19 (0.85) | 0.05 (.82) |
| Executive function | 0.18 (0.10) | 3.41 (.065) | 0.02 (0.04) | 0.38 (.54) |

[a] Control+CCI was taken as reference;
[b] Baseline was taken as reference; df = 1 across analyses.

*Time* × *Group* + ε. In this GEE model, "Time" was considered a dichotomous variable coded 0 for baseline and 1 for later time points. Thus, the group comparison focuses on whether one group showed better improvement on average across all follow-up points. Paired t tests within each group examined differences between baseline and later assessments.

Secondary analyses examined whether changes in attitudes toward computers were associated with a better CCI effect on cognitive outcomes, regardless of treatment group. This analysis involved identifying trajectories of attitude improvement via a latent class growth analysis (LCGA) across all participants (n = 49). We then examined GEE models with AR(1) similar to that above, but with class membership, rather than intervention group, as the primary independent variable.

## RESULTS

### Sample Characteristics

Enrollment started on 10/24/2017, while data collection was completed on 4/15/2019. Sample characteristics are presented in Table 1, and the CONSORT diagram outline participant flow from first contact to study completion is in Figure 1. There were no significant group differences on cognitive screening tests in participants who enrolled in the study. During the initial phase, the MICS + CCI group only conducted on average 7.29 hours (range: 0−34.17 hours) MICS practice. The rationales for not practicing MICS included: "had no interest," "preoccupied by other activities," and "MICS interface system not user friendly." The average amount of practice on CCI was 13.92 (range: 0.28−32.08 hours) and did not differ between groups.

### Primary Analyses

There was no significant group by time interaction on ATCQ or cognitive outcomes at the end of 4 week or across time points (Table 2). Thus the groups did not differ on the extent to which they improved. There was no significant group difference in the amount of CCI use (14.48 ± 6.75 hours versus 13.40 ± 9.58 hours, t = 0.43, df = 40, p = 0.67).

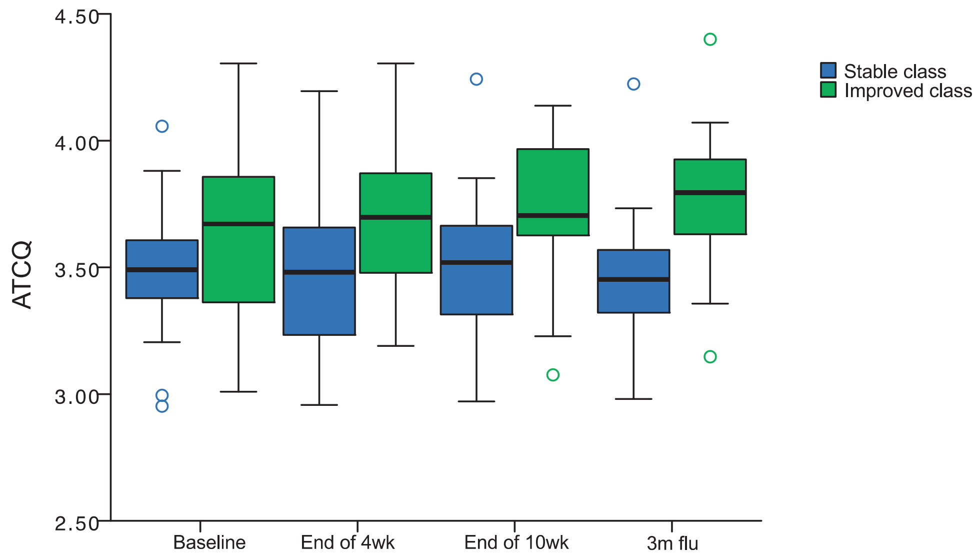
Within groups, there was a significant improvement in executive function in MICS + CCI group from baseline to 4 weeks (t = −2.01, df = 21, p = 0.058), 10 weeks (t = −5.04, df = 21, p <0.001), and 23 weeks (t = −2.81, df = 21, p = 0.010), while the only significant improvement in CCI group was between baseline and 10-week follow-up (t = −4.67, df = 20, p <0.001). There was no improvement in ATCQ or episodic memory in either group. The standardized mean difference (Cohen's d) for changes from baseline were, for the MICS + CCI group, 0.32 at 4 weeks, 0.85 at 10 weeks, and 0.46 at 23 weeks. For the CCI only group, they were d = 0.05, d = 0.82, and d = 0.45, respectively.

Of note, when limiting the use of MICS to ≥ 10 hours to define compliance to the intervention, there was no difference in ATCQ, episodic memory or executive function over time between the MICS + CCI (n = 7) and CCI only groups, which may due to the small sample size. Also, there were no difference in baseline ATCQ or ATCQ change from baseline to 4-week follow-up for those who use MICS 10 hours versus MICS <10 hours.

### Secondary Analysis

LCGA analysis identified two classes (Fig. 2): class one (n = 27) had stable ATCQ over time [Intercept: B

**FIGURE 2. Latent class result for classifying ATCQ over time.**




(SE) = 3.50(0.05), df = 1, $\chi^2$ (p) = 5225.56(<0.001); Slope: B(SE) = −0.02(0.01), df = 1, $\chi^2$ (p) = 1.96(0.16), labeled as "stable" ATCQ]; class two (n = 22) had improved ATCQ over time [Intercept: B(SE) = 3.59 (0.07), df = 1, $\chi^2$(p) = 2449.53(<0.001); Slope: B (SE) = 0.04(0.01), df = 1, $\chi^2$(p) = 10.45(0.001), labeled as "improved" ATCQ]. The stable ATCQ class had 15 participants from MICS + CCI, and 12 from Control + CCI; the improved ATCQ class had 9 participants from MICS + CCI, and 13 from Control + CCI. Since age, sex, and group assignment had been controlled when conducting LCGA analysis, there was no difference for the two classes in these variables.

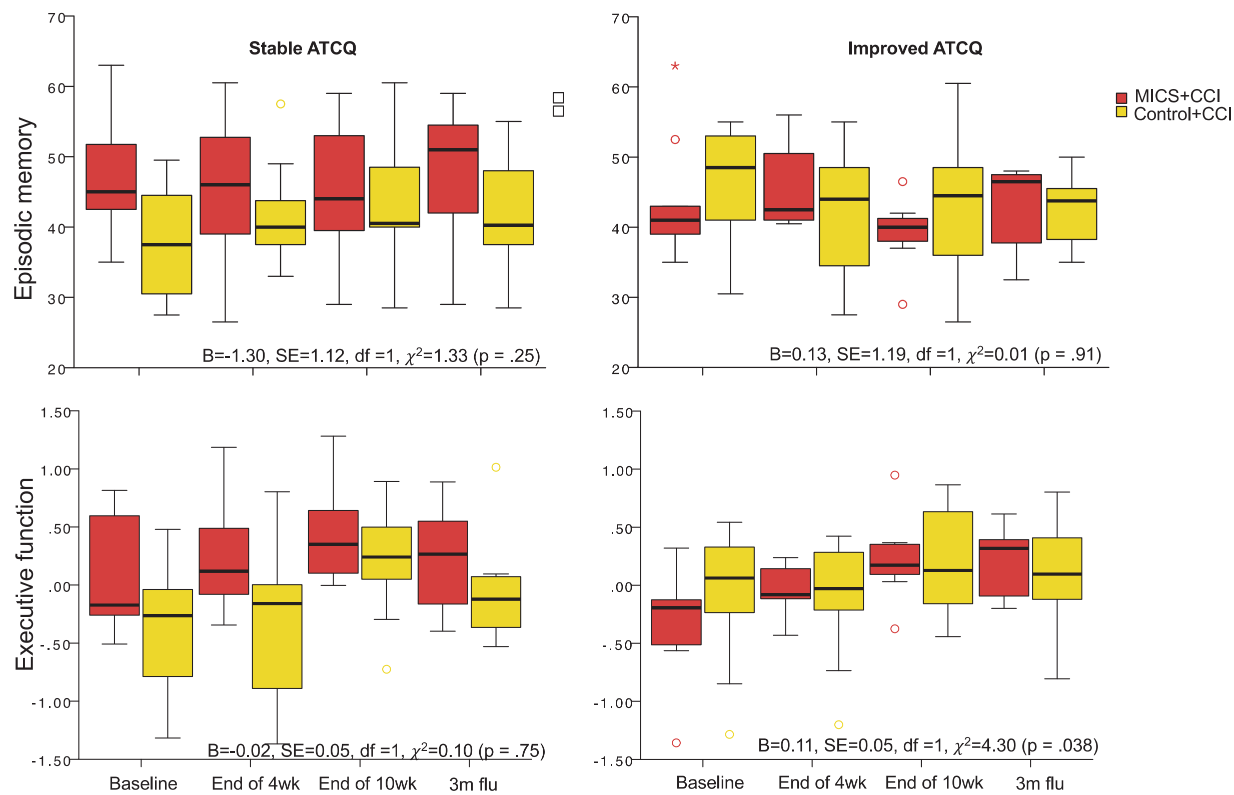
Next, we examined whether cognitive improvement differed according to ATCQ class. There was a significant time*group interaction effect such that the improved ATCQ class showed significantly greater improvement in executive function than the nonimproved ATCQ class (Fig. 3; improved ATCQ class change in executive function B(SE) = 0.11(0.05), df = 1, $\chi^2$(p) = 4.30(0.038), stable ATCQ class B(SE) = 0.02 (0.05), df = 1, $\chi^2$(p) = 0.10(0.75)). The moderation result indicated that individuals whose attitudes toward computers showed more improvement also showed better test performance. There was no significant difference between the classes in improvement in episodic memory.

## DISCUSSION

We conducted an RCT among the oldest-old senior living center residents with MCI, aiming to understand two questions:[1] whether attitudes toward technology use can be enhanced by tailoring the computer use based on their interest;[2] whether improving attitudes toward technology use can further enhance cognitive outcomes from a well-established CCI. Results indicate that the intervention, MICS, did not improve attitudes toward computers. However, secondary analysis indicated those whose attitudes did improve, whether through MICS or simply exposure to the CCI itself, did show greater executive function improvement.

Of note, we expected participants to use the MICS device 5 hours/week based on pilot data, compared to the actual average use time 2 hours/week. The reasons for infrequent use of the device were related to the difficulty in use the interface, lack of interest, and no time. This lack of use may explain the lack of change in attitude scores among the MICS group. Although the MICS is a computer itself, its design is intended for amusement and pleasure, rather than the mentally-demanding test-like qualities of a CCI. It is possible that because the MICS is still a piece of

**FIGURE 3. Trajectories of episodic memory and executive function over time by ATCQ latent class. No latent-class difference in episodic memory. There was a significant time × group interaction effect in executive function: improved ATCQ class showed significantly greater improvement in executive function but note in Stable ATCQ class.**




technology, it was regarded as less appealing than traditional media familiar to older adults of this cohort, such as television or books. This poses a dilemma in efforts to promote older persons' engagement with CCIs, because technology must be experienced at some level to gain familiarity with it.

One way to overcome the reluctance to engage with MICS might be to structure and supervise older adults' use of them, so that they cannot merely ignore MICS when these systems are given to them. The present design attempted to provide this structure to some degree with an introductory orientation and help line, but this does not appear to be enough. Facilitators may need to actively assist older adults in regular use of MICS for it to become self-sustaining. In other cases, individuals might never voluntarily use MICS. Both premorbid cognitive ability, as well as openness to experience, are also likely to affect interest in the MICS.

The present results must be interpreted in light of study limitations. First and foremost, this was an exploratory/developmental project intended to probe the hypothesis that adding MICS to a traditional CCI could boost engagement and improve attitudes toward computers. It was not a large trial, and thus there is the possibility that some effects of interest might not be detectable. Correction for multiple testing was not applied. Thus, findings should be interpreted cautiously and in light of effect sizes as well as statistical significance. In addition, practice effects can occur, even when alternate tests forms are used. These cannot be ruled out as one source of improvement. Nonetheless, the results do provide important information for future efforts, particularly around the need to structure and standardize the MICS or similar gateway interventions around technology. We also focused specifically on the oldest-old group with MCI in independent living facilities. Potentially, studies of older persons without MCI or younger individuals might yield different findings. The rationale of targeting this particular group in independent living facilities was to prevent transition to more severe forms of dementia. Future work might consider targeting cognitively unimpaired persons with the aim of preventing transition to MCI itself. Independent living facilities provide the possibility of external structuring of MICS use, as they include staff and can manage group implementation. MICS use outside of independent living facilities remains unknown.

Ultimately, MICS use was conceived as simply a means to the end of improving computer attitudes and boosting CCI intervention. One important finding of this study is that among persons whose attitudes toward computers do improve—whether through MICS or simply exposure to any computers−−executive function improved. This result underscores the potential importance of older adults' attitudes toward computers as an intervention target.

## AUTHORS CONTRIBUTION

Lin provided initial drafting of manuscript, analyses, interpretation, critical revisions; Chapman initial drafting, interpretation and critical revisions; Cottone, McDermott, Jacobs, collection and analysis of data; Nelson and Porsteinsson provided critical input during drafting and revision.

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