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ORIGINAL ARTICLE

Feasibility study of an attention training application for older adults

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Background. Technology-based attention training has demonstrated promise in its potential to improve cognitive functioning in older people. Developing mobile applications, with older users specifically in mind, may support future dissemination of these interventions and integration into daily life.
Aims and objectives. The purpose of this pilot study was to test the feasibility of an Attention Training Application (ATA) for community-dwelling older adults using mobile technology.
Design. A descriptive, mixed-methods design was used to capture older adults' feedback on the usability and acceptability of the ATA.
Methods. A convenience sample of older adults (n = 9) from two independent living facilities participated in a 2-hour training and practice session with the ATA. Participants were given personally tailored instructions for using the mobile device and the ATA specifically. Following a practice session, participants provided ratings on multiple components of the ATA and completed an audio-recorded, semi-structured interview to provide detailed descriptions of their experience and perceptions. An iterative process of content analysis was used to characterise the open-ended responses.
Results. Participants rated the ATA favourably overall on several 0–10 scales including likeability [8.5 (1.6)], interest [8.8 (2.3)] and satisfaction [8.2 (1.9)]. The

qualitative analyses revealed several issues relevant to the feasibility of the ATA among older people including the importance of the technological background of the user, limiting negative feedback, challenges with the touch screen interface, personal preferences for challenge, extending the practice period and the difficulty of the dual-task condition.

Conclusions. The use of the ATA is feasible in the older adult population. Future development should specifically consider personal characteristics as well as preferences to maximise usability and acceptability among older people.

Implications for practice. Older adults enjoyed the ATA. This opens doors to user-friendly technological interventions that may be effective in assisting older adults maintain and possibly even improve their cognitive function.

Key words: cognitive impairment, gerontological nursing, information technology, mixed methods

What does this research add to existing knowledge in gerontology?

- This study addresses the need for the perspective of older people in technology development relevant to improving cognitive function.
- Older adults are interested in using mobile apps such as the Attention Training Application (ATA), but age-related issues as well as personal preferences should be considered.

What are the implications of this new knowledge for nursing care with older people?

- Nurses should consider the potential of mobile technology-based applications for older adults with an interest in learning and/or using mobile devices.
- Individual characteristics and preferences may play a significant role in engagement, and potentially benefit, from technology-based interventions.

How could the findings be used to influence policy or practice or research or education?

- The use of mobile technology is growing among older adults and may be an important platform for dissemination of cognitive interventions in community settings.
- Future research examining the role of technology-based cognitive interventions for older adults should include feedback from the target population in all aspects of development.

Introduction

Preserving healthy cognitive function is critical for quality of life and controlling cost of care among older people, and cognitive interventions may maintain or improve cognitive functioning (Acevedo & Loewenstein, 2007). The proliferation of mobile technology can address several limitations to implementation of cognitive interventions in community settings including integration into daily schedules, potential reduction in implementation costs, as well as opportunity for wide scale dissemination (Herrera *et al.*, 2012). Developing these interventions by considering feedback from older adults themselves is a critical need. While a touch screen interface allows for essentially complete freedom of design and interface options, the perspectives and input of older people should directly influence this process. Older adults are the fastest growing users of computers and the internet; 53% of Americans age 65 or older use the internet or email and 69% own a mobile phone (Zickuhr & Madden, 2012). The use of a mobile application, or app, to deliver cognitive interventions provides for customisation important to an older adult population such as simple design, consistent screen navigation and content limited to the task at hand.

Many older adults express a positive view of technology and potential incorporation of technology into their daily lives (Mitzner *et al.*, 2010; Heinz *et al.*, 2013). In particular, technologies that can assist with maintenance of independence, physical and mental abilities are of interest, but the frustration associated with attempts to use technology as well as perceptions of a lack of assistance may be limiting factors (Heinz *et al.*, 2013). Research has demonstrated the ability for older adults to successfully learn to use mobile technology, specifically tablet devices, with adequate training and support (Arthanat *et al.*, 2014). Mobile technology has been utilised for health assessment (Bielli *et al.*, 2004), health tracking (O'Brien *et al.*, 2015) and behavioural intervention implementation (Kurti *et al.*, 2015) among older adults with positive feedback from users. Although older adults are generally open to learning how mobile technology may benefit them, training must be targeted and device interaction optimised with older adults specifically in mind (Parker *et al.*, 2013; Lee & Nguyen, 2014).

Cognitive training is an approach to cognitive intervention that involves repeated practice on tasks specific to particular cognitive domains such as memory or attention (Clare & Woods, 2004), and computerised cognitive training has emerged as an increasingly widely applied format. Improvements in task performance following computerised cognitive training have been demonstrated in cognitively intact older adults (Kueider *et al.*, 2012) as well as those with mild cognitive impairment (Coyle *et al.*, 2014). Therefore, cognitive training may be an effective approach for preventing, delaying or even treating cognitive decline among older adults. Computer-based delivery of cognitive training offers an important advantage over traditional paper-and-pencil approaches: automatic adjustment of the training's difficulty level based on individual performance (Kueider *et al.*, 2012). One specific paradigm, adaptive dual *n*-back training, has demonstrated not only the ability to improve performance on the task trained, but also transfer effects to improvements in mental flexibility, focus of attention and episodic memory (Jaeggi *et al.*, 2008; Rudebeck *et al.*, 2012; Lilienthal *et al.*, 2013).

Of note, dual *n*-back training targets the cognitive domain of attention, which is a prerequisite for higher-order cognitive processing and is essential for successful cognitive performance. For example, an individual will be unable to remember details of a specific event unless he/she was paying attention when it occurred. Attention includes the mental states and operations needed to detect stimuli, select stimuli over 'noise' and manage resources for the detection and processing of competing stimuli (Robertson, 1996). Deficits of attention lead to difficulties in everyday activities; therefore, improving attention among older people via dual *n*-back training may lead to real-world cognitive benefits. In addition, the use of mobile technology to deliver this training in the home setting can provide increased accessibility to many older people. This is particularly important as research shows most benefit from these training tasks are gained when individuals participate in training repeatedly over longer periods of time (e.g. months; Jaeggi *et al.*, 2010).

The purpose of this pilot study was to evaluate the usability and acceptability of an Attention Training Application (ATA), an app based on the adaptive dual *n*-back training paradigm, for community-dwelling older adults using mobile technology.

Methods

A descriptive mixed-methods study design was used. The combination of qualitative and quantitative components was selected for examining the usability and acceptability of the ATA among independent living older adults to provide both a rich description of the experience of using the mobile application as well as quantitative ratings of the ATA. Following enrolment, participants scheduled a 2-hour appointment with a member of the study team, either a psychologist or master's-prepared Registered Nurse, both experienced in working with many older adults across care settings. During the session, participants received individualised training on the use of the ATA depending upon their technology experience, practised using the three sections of the app both with the support of the study team member and then independently and completed evaluation forms as well as an audio-recorded interview.

Sample and setting

A convenience sample of older persons was recruited from independent living facilities within two continuing care retirement communities in Pennsylvania. One facility was located in an urban location associated with the local university. The second facility was located in a rural community. Permission was obtained from the activities directors at both locations to use a room within the community for maximal comfort and convenience of participants. Inclusion criteria included English speaking; age 60 or older; living independently (i.e. not a resident of an assisted living or skilled care nursing facility); and no cognitive impairment. Individuals with a score of 24 or greater on the Montreal Cognitive Assessment (MoCA), a brief screening instrument to assess for mild cognitive dysfunction (Nasreddine *et al.*, 2005), were considered to be free of cognitive impairment. Participants were recruited using flyers placed in resident mailboxes at both sites. The flyers described the purpose of the project as getting feedback on an application ('app') from older persons and included study team contact information for interested individuals. A brief phone screen was used to verify an individual met inclusion criteria and was available during the interview times.

The final sample consisted of nine older adults: seven females and two males; six from the urban community (M_{age} = 84.3, SD = 7.17, range 78–96) and three from the rural (M_{age} = 68, SD = 4, range 64–72). All participants earned a high school diploma and 56% obtained a college or graduate degree. Consistent with the demographic characteristics of the region, participants were all Caucasian. Due to the demographic similarities, data were collapsed across sites for further analysis.

ATA Development

The mobile *ATA* was developed for the iPadTM and iPad MiniTM using Apple's Xcode development tool. The adaptive dual *n*-back procedure was translated from the system described by Jaeggi *et al.* (2008) to a native iPadTM application. Dual *n*-back training consists of simultaneous presentation of visual stimuli on a computer screen (squares shown in one of eight positions on a grid; Fig. 1) and a sequence of auditory stimuli (spoken letters). On each trial, the participant must identify when either a spoken letter or a square position matched the one that appeared *n* trials back. In the adaptive dual *n*-back task, task difficulty is increased based on performance. Better performance leads to an increase in *n* levels requiring a participant to base their recall on trials presented further back in time.

The ATA included on-screen progressive training on use of the app as well as adaptive responses to task difficulty based on user performance. The goal of these adaptations was to ensure users understand the task demands while limiting potential frustration in individuals with different cognitive capacities and familiarity with technology. All participants were first introduced to the single *n*-back tasks, either visual or auditory stimuli presented alone, and provided the opportunity to demonstrate success with these tasks before progressing to the dual *n*-back task (visual and auditory stimuli presented simultaneously).

The ATA was designed to be a standalone app that could instruct the user how to interact with it, administer the training, give feedback and gather and display data on the training sessions. The interfaces were created to be intuitive and easy to follow, allowing for inexperienced iPadTM users to interact with ease. Much effort was put into the layout and functional flow, encouraging a top-down approach to the development cycle. Screens and user flows were laid out first, followed by basic interactions and finally core features. Development occurred over several cycles of implementation, testing, feedback and further development, allowing for features to be modified and improved. As use of the ATA could vary from the research context to casual at-home training, and users could have varying levels of cognitive abilities, the settings were designed with some customisation in mind, featuring a regimented treatment mode and a custom settings mode.

Measures

Participant questionnaire

This questionnaire was designed to capture demographics as well as familiarity with technology. The participants were provided a list of popular technology and asked which they used daily, weekly or monthly and also had the opportunity to add additional technology use and experience. Comfort level with learning new technology was also assessed.

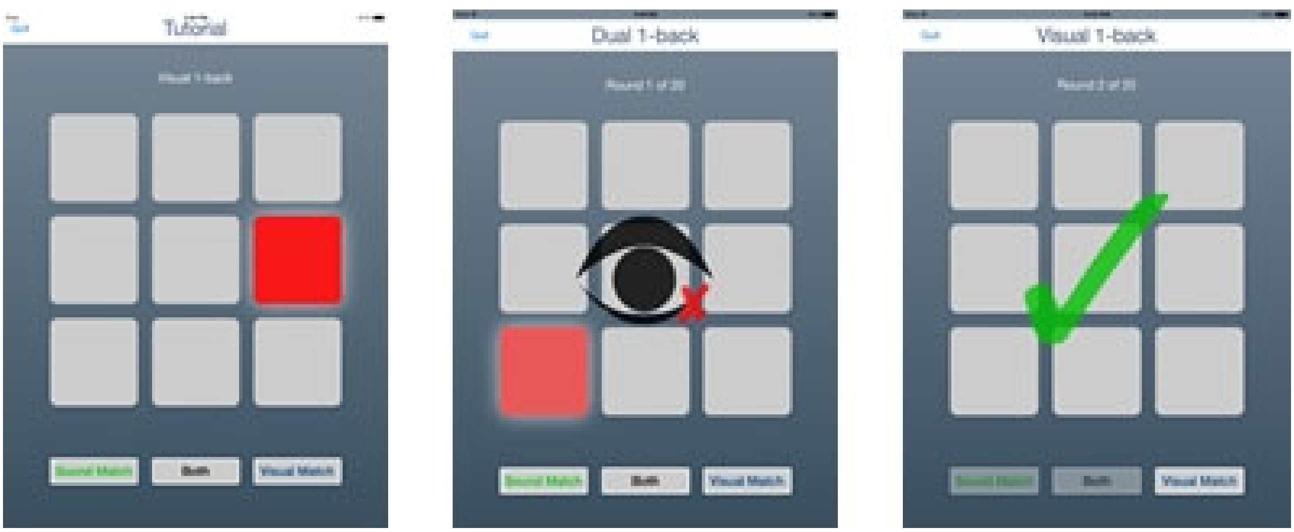

Figure 1 Attention Training Application screenshots.

ATA Evaluation
This tool was designed to allow participants to provide their general impressions of the ATA on a 0 (negative) to 10 (positive) in four categories: overall, easy, satisfying and interesting. Additionally, twelve specific feedback items were included that were assessed on a seven-point Likert-type scale ranging from Strongly Disagree to Strongly Agree.

Semi-structured Interview
Interviews were conducted at the end of the training and practice sessions to allow the participant to share their perceptions and also to allow the opportunity to expound upon questions answered in the ATA evaluation. Interviews were based on a semi-structured interview guide and audio-recorded. A co-interviewer took field notes during the process. Following the sessions, the audio-recordings were transcribed.

Analysis

Descriptive statistics were calculated for all quantitative data. The de-identified data from interviews and field notes were used for content analysis. During the initial stages of content analysis, low level codes were assigned as each piece of data was compared and contrasted with other data to build a conceptual understanding of the experiences of older adults using the ATA. As data amassed, higher level codes, called categories, were assigned as linkages were explicated. Quantitative data were used to contextualise the qualitative interviews.

Results

The sample was, on average, free of cognitive impairment (M = 26.63, SD = 1.77, range 24–29) and reported an average use of five technologies, with cell phone and internet being the most commonly used. Eighty-eight per cent of the sample reported daily cell phone use, and 56% reported daily internet use. Overall, the sample indicated an average comfort rating with technology of 7.1 (SD = 2.4) on a scale of 0–10.

ATA Ratings

The ATA evaluation form consisted of two parts: a general evaluation of the app, followed by specific ratings of individual app characteristics. Participants generally viewed the app favourably, rating it high in likeability (M = 8.5, SD = 1.6, range 5–10) and interest (M = 8.8, SD = 2.3, range 4–10). The app was rated moderately easy (M = 6.4, SD = 2.6, range 2–10). The app was also rated as relatively satisfying to use with an average rating of 8.2 (SD = 1.9, range 4–10).

From the more specific items evaluating different aspects of the app, participants rated it as easy to use and the instructions provided as clear (questions 5 and 9, respectively). Relevant to the goals of the current study, most participants would recommend the app to a friend (7 of 9) and agreed that the app was fun to use (8 of 9). Descriptive statistics for specific app characteristic ratings appear in the Table 1.

ATA Feedback

Content analysis identified several issues of relevance to ATA feasibility among older persons including design characteristics as well as technology-specific issues. The following section describes the categories of responses identified across participants, with particularly illustrative quotes provided.

Technological background of the user
Participants acknowledged potential challenges to technology use among older people, including the app itself as well as the device. Comparisons between older adults with and without technological expertise were made, such that users felt some of their peers were good candidates for use of the ATA, but others did not have the technical background necessary. Advanced age itself may be less of a factor in determining the acceptability of mobile technology-based interventions, and rather each individual's own past experience may be more important.

Well, it would be who I was recommending it to. It would depend on your situation. If you allow me to say it, as I get older, I find more

Table 1 Ratings of app characteristics

Item	Mean	SD	Range
It is easy to use	5.43	0.53	5–6
It is flexible	4.67	2.06	0–6
It is useful	5.67	1.00	3–6
It does everything I would expect it to do	4.75	1.49	2–6
The information and instructions provided were clear	6.00	0.00	6
The interface of the app was nice looking	5.00	1.20	3–6
I liked using the app	5.67	0.71	4–6
Both occasional and regular users would like it	4.75	1.28	3–6
It is easy to learn to use it	5.00	1.32	2–6
I would recommend it to a friend	4.89	1.76	2–6
It is fun to use	5.44	1.33	2–6
I am satisfied with it	5.88	0.35	5–6

people that are not using technology as much as when I was younger. It'd be more difficult to find people to recommend it to.

Simple interface with limited negative feedback

While the ATA task is conducted with a simple screen design consisting of a three-by-three grid of squares, the feedback that was provided to users about correct or incorrect responses was overwhelmingly considered to be distracting and frustrating (Fig. 1). There were a variety of icons used in the ATA to notify users of incorrect responses, such as identifying a missed auditory prompt or a visual prompt or both.

Yeah, it was distracting to me. I was trying to read that thing after I made a mistake and I didn't know what the heck it was for.

. . . once I've made a mistake, then your mind goes crumbly and then you start at the beginning, 'What did I do wrong? I thought I did that right.' And I didn't. You try to analyze it and when you do that, you go to the next step and you lose that one completely.

Challenges of touch screen interface

Many participants were interested in learning about the use of the iPad™ device itself, although specific usability issues were noted, particularly related to responsiveness and the tactile aspect of a touch screen device. Past experience with technology tended to be using desktop or laptop computers with keyboards; navigating a device entirely using fingers on a screen was unfamiliar and uncomfortable for some users.

Really, I like to use a mouse. I feel more comfortable in that. Touch screen works. I'm not as good at that, but then I haven't been doing it as much. I started using a mouse 20-some years ago, well more than that, 40 years ago almost.

And I found myself, I thought I did that right. And did I press hard enough or did I not press hard enough?

Throughout the app testing period, study team members also recorded many instances of the device not responding to the taps of the user. It was unclear whether this was due to slow response times or other issues such as finger dexterity or peripheral circulation.

Individual preferences for challenge

In general, the use of the app was described as fun and enjoyable. More specifically, individuals who enjoyed using the app described appreciating the challenge it presented and referred to feelings of accomplishment when they were successful with the tasks. As opposed to the feedback icons presented when an incorrect response was given, the positive feedback icon was considered a motivator by users and an important indicator that they were making progress (Fig. 1).

. . . it was fun to see that you could either hear or see correctly, even the little check mark. Even just that little check mark made you feel good about yourself.

Because I wasn't getting frustrated. I was just getting that I can do this, let me try again. And I gradually got up a little bit each time.

Frustration with dual task

The first two tasks practised by participants, the visual and auditory cues alone, were perceived as enjoyable. The dual task, as to be expected, was much more challenging for users, to the point of being frustrating for many. Several participants ended their practice period prematurely when faced with the dual *n*-back task.

I just became confused when we were doing the two together.

Well, putting them both together was very difficult. My coordination for that was not good.

Additional practice time

The training users received from the study team prior to trying the app was referenced as being necessary and effective. Having an opportunity to see what the app would look like and a video tutorial of how it would perform during the task was found to be helpful. Although this training was considered adequate, there was a consistent need identified for more time to practice, in private and on their own time.

I think it was very helpful for you to show my how to do it the first time, rather than try to learn to do that on my own.

I'll tell you what, give me a couple of hours on this thing in my privacy and I'll learn to do it.

Perceived benefit of cognition-focused apps

Participants described the ATA as a 'brain game' similar to other computer games they may play as a leisure activity, although they recognised that the ATA had specific goals of improving cognitive ability in some way. Although many did not mention attention specifically as an area targeted by the app, they did discuss relevance to everyday tasks with a focus on attention-related functioning, such as the ability to concentrate. However, several participants also discussed the need for the app to be more interesting or have a specific purpose or theme in order for them to want to use it. Most people felt that an app which required extensive cognitive processing as important, particularly for older adults, and expressed an interest in using the ATA on their own, in their home environment.

It helps you to concentrate, which tends to be a problem sometimes in this everyday world. So, I think it's good to teach you to zero in and concentrate, think about what you're doing.

... it would be a great thing for people to have on their brain apps because as you get older, especially your shortened term memory. When you played Fish as a little girl or that game where you picked up cards and remembered where a card was and if you got a pair, you got to throw it away, remembering those is difficult. Oh, I can see many uses for this.

Discussion

This pilot feasibility study focused on obtaining feedback from older people to inform the future development of mobile technology specifically focused on maintaining or improving cognitive abilities. Much attention is paid to certain aspects of technology development for older adults, such as visual contrast and simplicity in navigation, but this study identified additional characteristics that may be particularly important when targeting cognitive processing within a mobile app. While no questions were specifically asked regarding advancing age and technology use, participants responded to many questions with age-related references; for example, 'We're different, we're all old people'. Therefore, at least some of the stereotypical perceptions of older people using technology seem to be present in this age group. Including older adults' feedback throughout the process of app development may help to overcome these barriers and ultimately result in an end product that is more usable and enjoyable.

Several areas of feedback specific to the ATA itself are important for future development of this approach to attention training among older people. Determining an optimal level of feedback to support cognitive training among older adults is likely complex, particularly in this context when both the use of the technology itself and the cognitive task at hand are challenges to the user. Older adults have been shown to learn more effectively when provided positive rather than negative feedback (Eppinger *et al.*, 2008), which may have played a role in participants disliking the negative feedback icons after making mistakes during training. Also, considering the frustration experienced by many during the dual *n*-back task, additional time and alternative practice modalities in preparation for using the ATA may increase users' self-confidence, allowing errors to be perceived as more acceptable and decreasing the pressure that may be felt regarding performing well.

Additionally, special consideration to sensory issues must be made when developing technology for older people that considers the process of use rather than just the content of the app. Our study team made individual adjustments to the visual aspects of the device (e.g. modifying room lighting to limit screen glare; increasing screen brightness), sound volume and device position in older to optimise the experience for each user. Even with the one-on-one modification of the device to maximise usability, some users experienced difficulty with the responsiveness of the touch screen device. If this finding is present in larger studies, an examination of physical factors underlying this difficulty would be warranted. The use of a stylus, rather than finger taps, may be a better choice for some older adults.

Individual differences in response to cognitive training are also important to consider. Identifying older people who are more likely to participate in as well as benefit from such interventions based on certain characteristics, such as personality traits, may help to identify best candidates for targeted interventions. Personality has been associated with treatment effects, motivation, performance and treatment adherence across differing populations (Judge & Ilies, 2002; Chapman *et al.*, 2007; Conner *et al.*, 2007; Franks *et al.*, 2009). Among older adults with cognitive impairment, the personality traits of agreeableness, conscientiousness and openness have been associated with engagement in a cognitive intervention (Hill *et al.*, 2014). Additionally, our past research found that individuals with a resilient personality type (i.e. well-adjusted, emotionally stable and self-disciplined) benefited more from participation in mental activities than those with an overcontrolled personality type (i.e. reserved, competitive and unreliable) [blinded for review]. Given our findings that some participants enjoyed the challenge of the ATA and were motivated to continue using it after being rewarded with success, personality may play a role in cognitive training preferences and benefits.

This study had several limitations including the small size and homogeneity of the sample. However, our mixed-methods approach provided for rich descriptions of older persons experiences in using the technology as well as their perspectives of cognitive training interventions. While much attention has been focused recently on the potential of 'gaming' to improve cognitive outcomes among older people, this study utilised an evidence-based approach to cognitive training. Perhaps most importantly, the perspective of the older persons themselves throughout the process of learning to use the ATA and their reflections on its use were the focus of our investigation.

Older people are growing consumers of technology, and consequently, the development of technology-based approaches to maximise their everyday function must keep pace with this changing demographic. Much emphasis is put on person-centred interventions, but the perspectives of older adults are often absent from the process of technology development. As the population continues to age, more and more older adults are aware of, interested in, and reliant upon technology. Understanding the role of and preferences for technology within the older adult population may allow researchers and healthcare providers to use these resources with the older adult to create a more effective plan of care.

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Implications for practice

- Nurses can use mobile technology to support older adults engagement in healthy behaviors.
- Experience and comfort with technology are important indicators of whether a technological intervention will work with an older adult.

Contributions

Study design: NLH, JM; data collection and analysis: NLH, JM, EC and manuscript preparation: NLH, JM, EC, RD, JH, FVL.

Conflict of interest

No conflict of interest has been declared by the authors.

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