Brain Games and the Elderly:
Improving Cognitive Function using Gerontechnology

W. Scott Parry, Sumit Banerjee, Christopher O'Shea, Jean Coppola, Barbara Thomas
Seidenberg School of CSIS, Pace University, White Plains, NY 10606, USA

Abstract

As people age they are susceptible to decreased memory function. The gerontology academic and scientific community would like to collect more data on how decreasing memory function progresses over time. The Gerontechnology Web Site project will build a Web site which will be open to the public and promoted by the gerontology community to the elderly. The Web site will contain a series of memory and cognitive games. Registered users will attempt to master those games through successive attempts. The results will be tracked in a database available to researchers for use in furthering the scientific body of knowledge on the aging process and decreased memory and cognitive function.

1. Introduction

Gerontechnology is a term used to describe the application of technology to the study of gerontology. The goal is to promote scientific discovery of the ageing processes that will lead to technological innovations to improve the lives of elderly individuals by sustaining good health, comfort and safety[1]. The term Gerontechnology was first used by Mr. Jan Graafmans in 1989 at the Annual Meeting of the Human Factors Society [2]. Mr. Graafmans later became a founding member of the International Society of Gerontechnology, which was founded in 1997.

A Gerontechnology project in Westchester County was started in the fall 2005. Primary project partners include Pace University, Westchester Community College, United Hebrew (New Rochelle), and Westchester County Department of Senior Programs and Services. To date the project, which began in the Spring of 2006, has trained over 170 undergraduate students to teach intergenerational computing classes to the elderly in Westchester County. This has opened the world of computers and the Internet to elderly residents in independent living, assisted living, nursing home, and adult day care facilities.

The second part of this project is to develop Web-based technologies to: a) stimulate cognitive functioning of the elderly to improve their overall quality of life, and b) collect useful statistics on the increase or decrease of cognitive function for gerontology researchers. The Gerontechnology Web site project is the continuation of this second part of the project.

2. Other Gerontechnology Research Work

Gerontechnology is becoming a recognized interdisciplinary academic field and sits at the intersection of fields of Computer Science, Medicine, Psychology, and Gerontology. Some of the leading academics performing research in this subject include Dr. Gary Small of the UCLA Center on Aging, Dr. Paul Nussbaum of the University of Pittsburgh, and Dr. TJ McCallum of Case Western Reserve University.

Dr. McCallum of Case Western Reserve has spearheaded another similar Gerontechnology program called the Brain Emporium, a joint research program with Case Western Reserve University and the Fairhill Center, an elderly facility in Cleveland Ohio. The Brain Emporium houses eight computers with Nintendo Wii and other games. Elderly volunteers play the games and their ability to master the games is recorded by researchers [3]. Dr. McCallum reported, "These works are definitely improving people's acuity and other aspects of cognition."

Drs Majd Alwan, and Jeremy Nobel in their research report titled: *State of Technology in Aging Services.* and published by the Center for Aging Services Technologies (CAST), offer an excellent overview of the challenges in using technology to improve the lives of the elderly:

"Robust studies are needed to quantify the value of Gerontechnologies. Efforts to develop a set of strategies that enable health information exchange by linking data from different care related systems must be accelerated to enhance efficiency of care, as well as the safety of seniors. Finally, technology providers must work together and with other stakeholders to create successful business models for development and deployment of Aging in Place technologies that enhance the health and independence of older consumers."[4] "Several actions are recommended to advance the development and adoption of technologies that enhance the independence, health and quality of life of the growing older population. Those activities include the following:

- o Raise awareness of benefits of aging services technologies among many audiences.
- o Support research that proves the value of aging services technologies.
- o Design and market technology with older consumers in mind.
- o Develop the infrastructure necessary to make broad-based technology initiatives effective.
- o Provide incentives for various stakeholders to invest in technology
- o Encourage collaboration and ingenuity among technology providers." [5]

Other identified research projects recently completed in the field of Gerontechnology include research around individual technologies that are being explored to assist the elderly.

The following research project was to identify the capabilities of elderly impaired individuals in filling out online forms and to use that research to design online forms which are more user friendly to elderly individuals. *Developing and evaluating web-based assistive technologies for older adults. Published by* Gerontechnology in 2009*; by A.G.* Money, S. Fernando, L. Lines, and A.D. Elliman "Delivering Inclusive Access to Disabled and Elderly Members" (DIADEM) of the community is a three year Framework 6 European Union (EU) funded project. The primary goal is to develop the DIADEM application, a plug-in to a web browser that adapts the online-form interface according to users' needs, making the content more accessible for cognitively impaired older adults. After providing some background information relating to the DIADEM project and the DIADEM application, a trial protocol is presented. As one of the main contributions of this paper, the protocol has been specifically designed to identify cognitively impaired older-adults and to evaluate the usability of online-form content from an older adult user's perspective. To demonstrate the applicability of the trial protocol within the context of an ongoing research

project, details of a set of pan-European trials involving 77 eligible users, who evaluated DIADEM enabled online-forms according to the trial protocol, are also presented. Results of the trials reveal a number of online-form design guidelines, which will be incorporated into future versions of the DIADEM application. Although these guidelines have been developed specifically for the DIADEM application, they also represent valuable guidelines for online-form developers more generally, and if adhered to, will ensure that content is more usable for the cognitively impaired older adult user group. This paper concludes by discussing the lessons learned from implementing the trial protocol and how the implications of the findings of the DIADEM user trials may be incorporated into future versions of the DIADEM application[6].

This research project researched and enhanced the position that gathering an autobiographical review of an individual could help assess the cognitive capabilities of an elderly individual. *Adult Creativity and Gerontechnology's Goal for Enhancement of Quality of Life* by James L. Fozard, attempts to provide some links between gerontechnologies and creativity in adulthood. The material on creativity is derived from writings of James Birren, PhD, (Birren and Deutchman, 1991) Gene Cohen, MD, PhD (Cohen, 2000, 2005) and Robert Butler, MD Butler, 1963), pioneers in gerontology research, geriatric medicine and psychiatry, and public policy related to aging. Birren and Butler have made the case for using autobiography or "life review" as a therapeutic tool for elderly persons with depression and for enjoyment, self-fulfillment, and intergenerational communication. While agreeing with Birren and Butler, Cohen goes on to view autobiographical activities in a larger context of a strong personal urge for creativity that manifests itself in the later part of life[7].

3. Methodology

As Alwan and Nobel discuss, robust academic research studies are needed to support the anectdotal evidence being collected in the nursing homes and assisted living facilities where the elderly reside. The Gerontechnology Project's primary goal it to build a comprehensive Web site to support the Gerontechnology research being conducted. The Web site will serve: i) as a resource where elderly users can exercise their brain with interesting online challenge games, ii) to further work in the area of improving brain cognition by accumulating data as a longitudinal study, and iii) to improve dissemination of information for replication as a repository of documents for those agencies interested in replicating the study.

Project Objective #1

The first objective will be to create a Web site whereby any older adult will be able to create a unique user ID and log into the Web site. Appropriate freeware games/brain exercises programs will be provided to the older adult to improve the parts of the brain that need improvement.

Project Objective #2

The second objective of the website is to provide a repository of accumulated research on how individual Users are progressing in their ability to master the brain games and exercise. The scores of the games will be saved and tracked by User to determine if improvement has been made and periodically compared to original score.

Project Objective #3

The third objective is to house documents that can be easily re-uploaded by any member of the research team that would allow our model to be replicated by outside agencies, as well as support inquiries emerging from presentations, workshops, media coverage, and publications.

As a multi-year project and a not-for-profit venture, the Web site will be developed over time by a variety of mostly-volunteer developers. The initial Web site was developed by Computer Science students at Pace University. The first development team determined that Ruby On Rails would be the Web application framework program because of its flexibility to interface with numerous other applications. Unfortunately it is a language that is not universally known. With the reality that this project will be handed from team to team over time, it became apparent that the language would have to be changed to a more common and more well-known language. It was decided that standard PHP scripting language would be used with a MySQL database. These are standard open-source technologies and well known by student developers.

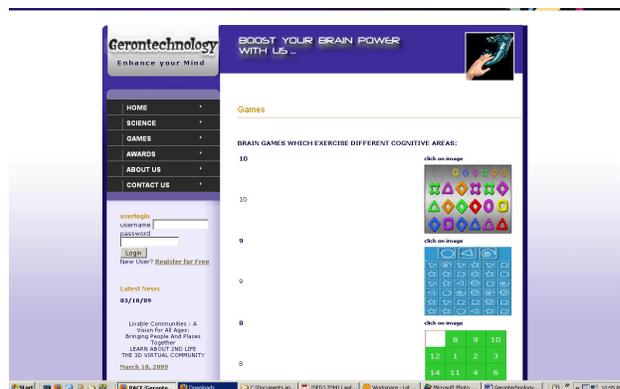Figure 1: Screenshot of Gerontechnology Web site Home Page

Figure 1: Screenshot of Gerontechnology Web site – Games Page

4. Requirements Gathering

An initial requirements gathering process was performed with the project sponsor. From this meeting, the following Use Cases were created and approved.

Use Case 1:
User registers for site
- Create Login protocol on UI
- Create User Information Table:
  - User Name (unique char 25) unique,
  - Password (char 15)
  - List of Challenge Questions (Picklist: questions)
  - Challenge Answer (text 50)
- Create password reset link on UI
  - Present Challenge Question when pressed
  - Ask for new password when challenge question answered correctly
- Append new fields to User Information Table:
  - User ID: (num 5) system generated, unique PK
  - First Name (char 25)
  - Last Initial: (Char 1)
  - Birth Year (num 4)

- o Gender (Picklist: Male, Female)
- o State: (Picklist: 50 states)
- o Country: (Picklist: countries)
- Create Prohibited_Words Table
- Whenever a User enters data that is saved, data entries should be checked against Prohibited_Words table prior to saving
  - o Message pops informing User that a prohibited word was used and to please change it.

Use Case 2:
Super Admin logs in and can view/edit all registered Users.
- Append three new fields to User Information Table and provide rights as follows:
  - o Super Administrators: (Y/N) Can View/Edit/Delete entries in User Information Table,
  - o Professional Users: (Y/N) Can login and upload docs and view Games_Played Table
  - o Regular Users: (Y/N) Can login and play games and view their personal Games_Played Table entries
- Search User Information Table for registered Users
  - o User Name, First Name, Last Initial, Age, Gender, State, Country, Access level,
- View/Edit/Sort/Delete from User Information Table
  - o User Name, First Name, Last Initial, Age, Gender, State, Country, Access level,

Use Case 3:
User logs in and is presented with a series of games to choose from. User selects a game, plays game, and games score is recorded. User can play same game an unlimited number of times and each time the new score is recorded as a new entry, without overwriting old score. User can view their own games played and scores.
- Create new Games_Played table
- User ID: link to User Information Table
  - o Event # :(num 15) system generated – unique key
  - o Game Name (text 50)
  - o Date/Time Game played (Date/Time stamp-system generated)
  - o Game score (num 10)
  - o Game scores are stored as new entries whenever a new game is played and score recorded
- View current logged in UserID's entries only in Games_Played Table
  - o Game Name
  - o Date/Time Game played
  - o Game score

Use Case 4:
Professional User logs in and views scores of games played and associated scores:
- Search Games_Played Table
  - o User ID, Game_Name, Date/Time Played, Game Score
  - o View Games_Played Table
  - o User ID, Game_Name, Date/Time Played, Game Score
- Sort Games_Played Table
  - o User ID, Game_Name, Date/Time Played, Game Score

Use Case 5:
Professional User can upload and delete documents to the site that any other Professional User can then View/Download.
- Create Upload Doc protocol on UI
- Limit size to 10 mg
- Limit type to Doc, pdf, xls, rtf,
- Create Document Table:
  - o User ID
  - o UserName
  - o DocID: (num 10) system generated PK
  - o DocName: (char 50)
  - o Doc location: (?)
  - o Date/Time Uploaded (Date Time stamp system generated)
- View/Delete User's own docs in Document Table
  - o Doc Name
  - o Date/Time Stamp
- Search Document Table for other docs
  - o User Name:
  - o DocName:
- View search results and download selected document
  - o User Name:
  - o DocName:

Use Case 6:
User logs out of application
- Create Log Out button and place on persistent area of site
- User is logged out when pressed

For future Development:
Use Case 7:
Website tracks and assesses the scores of each User, identifies weak skills in the User that need reinforcing, and suggests games to play to build those weak skills.

Use Case 8:
Improve the area of Web site on brain education. Show how each game improves a certain cognitive function of the brain.

5. Future development ideas

The next project team to take over development of the Web site will have to focus on four areas:

1) Release the Web site and start collecting research results from actual usage by the elderly. This will also include assisting the site sponsors with the collection of data and support of the administration of the Web site.

2) Improving the educational area of the Web site by showing what specific cognitive skills each game improves and what part of the brain that affects.

3) Connecting each game's cognitive skill improvement area to the scores of Users.

4) Building the ability for the Web site to recommend which game the User should play by recognizing low scores that may indicate a failing skill that needs improvement.

6. Summary & Conclusion

The Gerontechnology Web site will enable the Westchester Gerontechnology project to perform the scientific research work that has been called for by the Gerontology community in general. It will provide a valuable service to the elderly as they cope with reduced cognitive skills and limited capabilities for rehabilitation. At the same time, it will allow for the collection of research into how the loss of cognitive skills progresses over time. By providing access to this Web site to the general elderly population, the potential population of users is greatly expanded versus other studies that have been limited to a population of elderly limited to a single location. The increase of access to this project has the potential to increase the accuracy of the research by the volume of the research statistics collected.

This part of the project ended with the release of the Web site and therefore did not include actual studies of usage of the Web site. It is the hope of this project's participants that future projects will collect usage statistics to determine if the Web site is actually performing as it was designed.

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