CogStim Game to Prevent Age-Related Cognitive Impairment

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Abstract
In this paper, we present our ongoing research on developing a game grounded on evidence-based psychosocial intervention with cognitive stimulation. With a growing aging population, older adults want to actively preserve their memory in various ways. Based on brain plasticity and person-centered theories, we propose the CogStim game to help older adults exercise their memories, as well as monitor their cognitive functions through game play.

Keywords
Games for Health, Senior-Friendly Design, Cognitive Rehabilitation, Brain Exercise

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Human Factors

Introduction
Memory-enhancement activities are receiving increased attention by seniors and their caregivers. Even though

the efficacy of many enhancement trials is not yet proven, people are motivated to try them. This may be because there is no known cure for dementia, such as Alzheimer's disease. Therefore, a strong desire to prevent them can be a high motivation for seniors. Another reason could be that these activities are "safe" with no side effects because they are non-pharmacological behavioral activities.

Many senior citizens are concerned about their mental health and would like to act proactively to stay on top of their aging cognition. In the same way that they can check their blood sugar levels or monitor their weight in order to prevent cardiac-related diseases, they would like to be able to exercise their cognitive abilities, if possible. "Use it or lose it" is a popular proactive approach of trying to reduce the risk of cognitive aging. This approach is founded on the notion and analogy of cognition as a muscle. Consequently, it promotes seniors to actively use their brains through mental exercises, such as brain stimulation games. Research shows that cognitive exercises not only can improve cognitive outcomes, but can also provide predictive value in detecting cognitive impairment [1]. If the outcome of a brain exercise is monitored and found to be worsening, it may be a timely detection of initial cognitive decline.

We believe that everyday technologies can be used for seniors to maintain their mental health. In order to motivate seniors to practice their brain exercises through cognitive stimulation methods, we have taken the approach of designing and developing a technological intervention, the CogStim game.

Our Approaches

First, we explain why we are interested in developing a game for older adults to stimulate their cognition. Over the past year, we have built a quick-and-easy computerized screening system, called the ClockReader System [2-4]. The ClockReader System is a computerized Clock Drawing Test to detect the early stages of cognitive dysfunction [4]. The system asks a user to draw a clock and can then automatically evaluate the user's drawing, based on the evaluation criteria algorithm. The Clock Drawing Test is one of the most popular screening tests neurologists use in clinics [5]. An individual person's drawings of clocks provide useful information. For example, if a person has some cognitive difficulties, the clock they draw would not be a perfect clock (e.g., having all of the digits, as well as the two hands, in the correct position). The system would contribute to screening more people with cognitive impairments effectively, as well as efficiently.

Furthermore, we are planning to deploy the ClockReader system at an individual user's home to investigate the longitudinal use of a cognitive screening test. In this case, older adults can monitor and examine their cognitive status by simply using ClockReader at their home. However, we realize that there should be something provided to our users as a treatment. Since there is no cure for age-related cognitive impairment, screening alone may not be the best way to inform individuals of their diseases. This brought us to the question: in addition to the potential to delay cognitive impairment through early detection, how can we help our users maintain and practice healthy cognitive lifestyles?

We can provide our users with many possible intellectually stimulating activities. This idea leads us to the developing of a game for cognitive stimulation. Building upon our previous research on investigating a computerized cognitive impairment screening system, we propose the CogStim game. In the next section, we will explain the theoretical foundations of our game, especially focusing on the mechanisms of our brain.

Theoretical Foundations

Brain Plasticity & Cognitive Stimulation

Brain plasticity refers to the brain's lifelong capacity for physical and functional change. This capacity enables experience to induce learning throughout life [6]. It is because of this that when a certain part of the brain is damaged, and certain functions of the body governed by that part of the brain cannot be performed, the brain changes itself so that those functions are performed by other parts of the brain over time.

This is accomplished by synaptic pruning, a natural method by which the brain controls excess neurons [7]. Neurons that fire together are usually connected, and the ones that do not fire together are not connected. Thus, parts of the brain that govern certain functions contain neurons that fire at the same time. This process is continuous and goes on throughout a person's lifetime. This makes it possible to connect neurons from one part of the brain with neurons from another part of the brain, thereby transferring the knowledge of governing a function from one part of the brain to another part.

The Figure 1 showing the MRI scans of a person's brain illustrates brain plasticity. The first image (A) shows the part of the brain activated when the brain is normally functioning. The second image (B) shows a scan of the same brain after a traumatic injury, and shows that there is loss of activation (which results in loss of the body function). The third scan (C) shows the same brain after rehabilitation and shows a different part of the brain being activated for the same function.

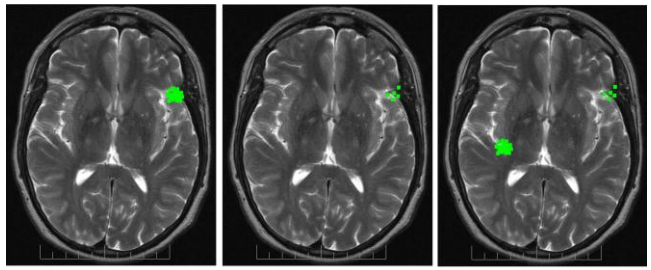

Figure 1. MRI scans of a person's brain

Not long ago, it was believed that the brain is plastic only during the early years of a person's life; however, there has been a recent shift in the consensus of researchers concerning the age at which the brain remains plastic. Some researchers believe that the brain remains plastic or can be trained to be plastic throughout life of the person [8].

Person-Based Approach

The Person-Centered Approach was first advocated by Tom Kitwood [9]. Kitwood argues that viewing people with dementia in medical terms leads them to be seen as objects and as having no subjectivity or personhood. He also states that people's experience of dementia not only arises from bio-medical phenomena, such as their degree of neurological impairment and their physical health, but also from social and psychological factors,

such as their personal biography and day-to-day interactions with other people.

Kitwood defines personhood as "a standing or a status that is bestowed on one human being, by another in the context of relationship and social being" [9]. He claims that people with dementia do not lose their personhood, and that it can be maintained through relationships with people.

Design methodology: Personas

In order to understand our potential users, we use the persona generation method by describing a user archetype that can serve as a design process guideline. Our previous research activities, such as user interviews, surveys, and focus group meetings for developing computerized cognitive screening tests, facilitated the development of three different personas.

- Carl Taylor is a 69-year-old retired professor. He is healthy mentally, as well as physically. However, as a psychologist, he knows the fact that aging is the highest risk factor for Alzheimer's Disease and Related Disorders (ADRD). Since aging is not controllable, he likes to learn about techniques to maintain the current stage of his cognition. He plays poker and solves puzzles every day. However, repeating the same routine every day may become boring. Sometimes he wants to do other stimulating cognitive activities via clinically proven methods.

- Theresa Lin is a 48-year-old high school music teacher. Recently due to frequent forgetfulness, she decided to visit a memory clinic. After several thorough examinations, she found out that she is in an early stage of Mild Cognitive Impairment (MCI). Even though MCI is not Alzheimer's Disease (AD), people with MCI have an increased risk for progression to AD. Now she has a strong motivation to learn anything that can prevent AD or delay the disease. She investigates all of the possible ways to contain her symptoms. However, there are no systematic ways she can get help in this matter. Specifically, she has problems with remembering names of people she knows. She thinks that looking at her photograph books of people will help her learn about forgotten names.

- James Hanson is an 81-year-old carpenter. He used to build furniture, such as desks and chairs. As a designer, he still likes to draw and make physical models for his grandchildren. He lives by himself with his dog, Camera. Recently, his daughter noticed Camera's whimpering and the empty food bowl. James realized that he forgot to feed Camera several times in the past week. He would like to take care of his dog but he does not want his daughter to call to remind him or come to feed the dog every day. Instead, he would like to get help boosting his memory while maintaining his independence.

The three personas described above represent our target users and their desires to maintain or improve their cognition. In the next section, we will describe our proposed system, the CogStim game.

CogStim Game

As illustrated in the different personas, even though our target users are somewhat diverse, but they all could benefit from activities that would stimulate their

cognition. Furthermore, despite their cognitive vitality, they all want to proactively prevent further cognitive dysfunction. To make it easily accessible, we are developing the CogStim game as an iPad application for seniors. The iPad can provide (1) senior- friendly interaction methods, "touch rather than mouse-and-keyboard," (2) easy-to-carry anyplace at home or outside, and (3) flexible multimedia contents.

The CogStim Game can be implemented as several independent modules. Cognitive Stimulation (CS) exercises include tasks such as recalling recently learned items. For example, if a patient wants to practice remembering an acquaintance's name, he or she can play a name-face matching game in CogStim. Here is how such game works.

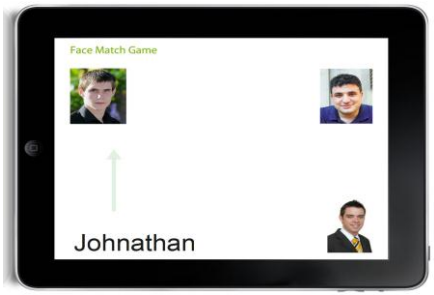

Figure 2. An example screen for the CogStim Game

First, the computer would show a blank screen, and the audio would instruct the patient to repeat these three words: James, Johnathan, Jack. Then the patient would view several images. Next after the 40-second viewing, the system would ask the user to recall the 3 words by providing the pictures of 4 items for the patients to select the right ones that they had heard. Figure 2 shows an example screen of the CogStim game.

It is common amongst Alzheimer's patients and persons with dementia to forget the steps taken to perform common household tasks like making coffee. A scenario to help such patients might include coupling instructions about daily activities (which the patient does not remember) with activities that the patient can and does perform on a daily basis. Whenever the person is presented with some information they don't recall along with some activity that they do remember and can perform the area of the brain that activates while performing the known activity eventually also takes on the job of remembering the information to perform another activity which the person may not otherwise remember.

Other scenarios of usage may vary; right from the patients using our system as a reminder system or an extension of their memories to our system being used as a full scale, non invasive and non pharmacological method of inducing or maintaining brain plasticity in aging patients.

Conclusion and Future Directions

Based on our first module of the CogStim game, our next step would be to speak with clinical researchers at Emory Alzheimer's Memory Rehabilitation Centers to determine the exact contents for the game. The application will record the frequency and duration of a user's brain exercise practice over time for future longitudinal study. The key research questions we try to explore are (1) whether CogStim would really have an effect on cognition improvement; (2) whether CS would affect people differently with different stages of cognitive impairment; and (3) whether monitoring the outcomes of CS would help detect the early stages of cognitive impairment.

We would not only advance our clinical understanding using Cognitive Stimulation, but we would also attempt to explore which factors of the game motivate seniors to practice engaging their brains. Games provide powerful first-hand experience that has the potential to motivate and improve learning, attitude change, self-concepts, skill development and many other factors known to lead to desirable health behaviors and outcomes [10]. However, most game design research

focuses on young adults or children rather than seniors. With our future research activities, we will explore how to encourage seniors through the activity of game play. Furthermore, our work will contribute to informing advanced knowledge in several research areas, such as senior-friendly design principles and games for health. By attending this workshop, we hope to share our research findings and learn from fellow researchers' experiences in design and developing systems to support reminiscence.

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