

# Lessons from Brain Age on Password Memorability

Alain Forget<sup>1,2</sup>, Sonia Chiasson<sup>1,2</sup>, Robert Biddle<sup>2</sup>  
<sup>1</sup>School of Computer Science & <sup>2</sup>Human Oriented Technology Lab  
Carleton University, Ottawa, Canada  
{aforget, chiasson}@scs.carleton.ca, robert\_biddle@carleton.ca

## ABSTRACT

User authentication involves establishing a user's right to access a system. Most user authentication is done with text passwords, which have advantages over other approaches, but more secure passwords are often difficult to remember. Nintendo's *Brain Age* games involve cognitive training which can improve memory. We examined Brain Age in search of insights towards helping users create and remember more secure passwords. Although Brain Age offers no techniques for memorising specific information, we discovered ideas for a new type of serious game that may help with password memorisation: *Password Rehearsal Games*.

## Categories and Subject Descriptors

K.6.5 [Management of computing and information systems]: Security and protection: Authentication; K.8.0 [Personal Computing]: General—*games*

## General Terms

Design, Human Factors, Security

## Keywords

Memory, passwords, serious games, usable security

## 1. INTRODUCTION

In computer security, the concept of user *authentication* involves establishing a user's right to access or modify system resources. Most authentication systems employ text passwords, and despite some weaknesses, they have advantages over alternatives: physical tokens can be lost or stolen, and biometrics can infringe on privacy. We are researching ways to improve users' ability to authenticate securely and easily with passwords. We found claims that Nintendo's *Brain Age* games improve memory. In our examination of Brain Age, we noticed the games might be adapted as a new type of serious game: *Password Rehearsal Games* (PRGs).

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

Future Play 2008 Toronto, Ontario, Canada. November 3-5, 2008  
Copyright 2008 ACM 978-1-60558-218-4 ...\$5.00.

PRGs could help users deeply *rehearse* their passwords while maintaining their engagement. Rehearsal is understood as a key technique to assist long-term memory [1], and thus might assist users at better remembering strong passwords.

## 2. BACKGROUND

The key issues in password authentication are password strength and password memorability. Password strength relates to how difficult it would be for an attacker to successfully guess the password. Unfortunately, users tend to choose easy-to-guess passwords containing common words and patterns [2]. Although online systems typically lock out attackers after a few incorrect guesses for a single account, attackers can target large numbers of accounts, giving them a good chance of guessing some of the accounts' passwords.

Increasing password strength is easy: a system can generate long random passwords that have minimal risk of being guessed. However, users cannot remember such passwords. We are exploring methods of making small improvements to password strength [3] and improving memorability.

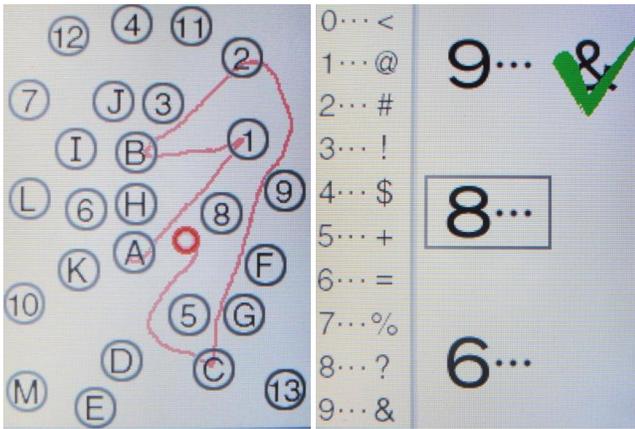
The *Brain Age* series, *Brain Age* and *Brain Age*<sup>2</sup>, are Nintendo DS games based on brain and memory strengthening activities proposed by Kawashima [4]. His neurophysiology and brain imaging research [5] founded exercises to develop and maintain good cognitive functioning. Brain Age offers brain training and testing games involving memory, language, and mathematical exercises.

In a framework guiding memory research, Craik and Lockhart [1] describe two types of information rehearsal. Deep processing and rehearsal of information, such as interactive and thought-provoking stimuli, leads to greater memory recall when compared to shallow rehearsal, such as basic mental repetition. They also state that longer deep processing and rehearsal times increasingly improve memory performance.

## 3. PASSWORD REHEARSAL GAMES

Our aim was to explore Brain Age first-hand, looking for design elements related to improving the memorability of strong passwords. We played the Brain Age games almost daily for approximately a month, making notes on design elements and discussing our findings.

We found that the games involve taxing memory exercises aimed at improving general cognitive functioning, as opposed to remembering specific information, such as a password. For example, if one wanted to remember a long complex password, the Brain Age games offer no suggestions, techniques, or explicit practice for such memorisation. However, some of the games may be adapted into Password Re-



**Figure 1: Two Brain Age games: Connect Maze, where players connect characters in the proper order, and Symbol Match, where players write the symbol associated with the presented number.**

hearsal Games (PRGs) to assist users with password memorisation in several different manners. PRGs present the user’s same passwords in different formats, allowing users to interact with their passwords in different ways. This can help users perform a deep rehearsal of their passwords, increasing the potential for memorisation [1]. Some users may also more easily remember their passwords if they can visualise them. PRGs can help such users discover visual mnemonics they can use to more easily recall their passwords. We now present some examples of PRG adaptations of Brain Age and other memory games.

**Word Scramble:** Brain Age’s Word Scramble presents jumbled words that users must quickly unscramble. A similar PRG could have players quickly unscramble jumbled password characters by entering the correct password.

**Symbol Match:** In our previous research [3], users often ignored symbols when selecting passwords because they are unfamiliar with typing them. Brain Age’s Symbol Match game (Figure 1) associates the numbers 0 to 9 each with a symbol. During game play, the system shows a number and the user must quickly enter the correct symbol. Symbol Match could be adapted to train users to quickly find and enter special characters on the keyboard.

**Connect Maze:** Connect Maze (Figure 1) players must quickly draw lines joining circles in sequence (A-1-B-2-C-3-...) without touching other circles. Users could be asked to connect account names to the correct passwords.

**Low to High:** In Low to High, users are given a 1-second glimpse of blocks containing numbers. Next, users are presented with corresponding empty blocks and must touch the blocks in increasing order based on the previously-shown numbers. A user’s password characters could be presented in jumbled order within blocks on the screen. When the characters disappear, users must identify the correct sequence of blocks corresponding to their password.

**Simon:** While contemplating Brain Age games, it occurred to us that this familiar memory game could also be used for password rehearsal. In Simon, an early electronic game, four coloured buttons are presented, each associated with their own sound. The system begins by lighting up one button and playing its sound. The player must repeat the action by pressing the correct button. The system then replays the original combination and adds one more button

to the sequence. The player repeats the new sequence. The game continues with ever-lengthening sequences until the player makes a mistake. A comparable PRG could introduce a password, one character at a time, having the user repeat the sequence so far. This approach might even help users memorise system-chosen random passwords.

**Memory:** Similarly, in the old-fashioned game of Memory, cards are placed face down and players may flip two cards at a time to find pairs. If a match is not made, players must return the cards face down and try to remember the cards’ positions for later matches. A similar approach could be used to pair account names and passwords.

## 4. DISCUSSION

These games are meant only as a supplement to the password authentication process, not a replacement. After creating a password in the regular manner using the normal interface, users could then quickly play one or more Password Rehearsal Games (PRGs) to help memorise their passwords.

PRGs must reveal the passwords to help users learn them. However, since passwords are meant to be private, and playing PRGs are not required to log in, PRGs are intended to be played only on a well-secured (malware-free) computer in a private area (free of shoulder-surfing).

Simple rehearsal of any information quickly becomes tedious and boring. However, the same can be said about doing the series of arithmetic calculations, reading aloud, and other memory activities Brain Age players perform on a daily basis. This is because the Brain Age games are designed to be amusing, engaging, and challenging. Similarly, PRGs could assist users in remembering stronger passwords by rehearsing them in a fun and interactive way.

## 5. CONCLUSION

We examined Brain Age for ways to help users remember more secure text passwords. We found that Brain Age aims to improve players’ overall cognition and memory. Unfortunately, Brain Age lacks any suggestions or techniques for recalling specific information (such as passwords). We explored some methods of adapting Brain Age and other memory games as *Password Rehearsal Games* designed to help users remember stronger passwords.

## 6. REFERENCES

- [1] F. Craik and R. Lockhart. Levels of processing: A framework for memory research. *J. of Verbal Learning and Verbal Behavior*, 11:671–684, 1972.
- [2] D. Florencio and C. Herley. A large-scale study of WWW password habits. In *ACM International World Wide Web Conference*, May 2007.
- [3] A. Forget, S. Chiasson, P. van Oorschot, and R. Biddle. Improving text passwords through persuasion. In *ACM Symposium on Usable Privacy and Security*, July 2008.
- [4] R. Kawashima. *Train Your Brain: 60 Days to a Better Brain*. Kumon Publishing North America, Teaneck, NJ, USA, 2005.
- [5] S. Uchida and R. Kawashima. Reading and solving arithmetic problems improves cognitive functions of normal aged people: a randomized controlled study. *AGE*, 30(1):21–29, March 2008.