Lessons from Brain Age on Persuasion for Computer Security

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Abstract
Users generally have difficulty understanding and managing computer security tasks. We examined Nintendo's *Brain Age* games for ways to help users remember more secure passwords. Instead, we found design elements that encouraged users to continually perform cognitive tasks that would otherwise be tedious. This paper discusses these elements using existing Persuasive Technology principles, and explores how they could be leveraged to make computer security tasks easier and more engaging.

Keywords
Authentication, Persuasive Technology, Usable Security

ACM Classification Keywords
J.4. Social and Behavioral Sciences: Psychology.
K.6.5. Management of Computing and Information Systems: Security and Protection: Authentication.
K.8.0. Personal Computing: General: Games.

Introduction
Computer security is generally difficult for users to understand and manage [1,9]. The dangerous errors caused by such usability problems often results in security vulnerabilities. Clearly, forcing users to take actions they do not wish or understand should be avoided. We believe innovative interface design can

guide users to voluntarily engage in secure behaviour rather than object and attempt to bypass the security.

We noted claims that Nintendo's *Brain Age* games improve people's memory. We closely examined the games for insights on how people could more easily remember stronger passwords. Although we believe the games could be adapted to aid in password memorisation [4], we also made a more profound discovery: Brain Age influenced us to remain engaged with what would otherwise be tedious memory and cognitive tasks. In this paper, we explore Brain Age's influential properties as Fogg's Persuasive Technology [3] strategies. We then consider how these strategies can be repurposed to motivate users to choose stronger passwords and behave securely in general. We believe Brain Age's persuasive and affective strategies could lead to middle-ground usable security solutions between mandatory user involvement and invisibility.

Background

Modern security systems have significant usability problems [1,9]. Since security is typically unrelated to users' primary tasks, many security systems aim to be as invisible and unobtrusive to users as possible [6]. However, this approach can lead to additional usable security issues. One problem is that malicious users are constantly trying to defeat security measures. Should an invisible security measure be circumvented, users will not know that something is wrong. However, visible security measures would at least provide users with a chance to realise something is amiss. Another problem is that computers are unlikely to always correctly interpret users' intentions. If security systems invisibly make decisions without user input, then users will be unable to inform the system of their true intentions.

Usable security guidelines [2,9,10] emphasise the need for clarity and visibility in feedback given to the user. As such, current research aims to reduce, but not eradicate, user involvement in security measures.

Persuasive Technology (PT) [3] includes a set of design principles based on psychological and behavioural research aimed at assisting people to achieve a desired behaviour or attitude change. PT has been used to help people eat healthier, exercise, and quit smoking.

The *Brain Age* series, *Brain Age* and *Brain Age*^{2}, are Nintendo DS games based on brain and memory strengthening activities proposed by Kawashima [8]. Brain Age offers brain training and testing games involving memory, language, and mathematical exercises. An avatar of Kawashima encourages players to improve their mental skills, offers advice on playing Brain Age, and suggests out-of-game mental exercises.

Persuasion in Brain Age

Our initial aim was to explore Brain Age first-hand, looking for design elements related to improving the memorability of strong passwords [4]. We played the games daily for over a month, while making notes on design elements and discussing our findings. The total time spent investigating Brain Age was over 100 hours.

In fact, we found that Brain Age offered no suggestions or techniques in memorising a *specific* piece of information, such as a password. The games instead aim to improve *general* cognitive functioning through taxing memory exercises. To our surprise, we found many design elements that might subtly influence users in powerful ways. We now discuss these elements using

figure 1. Screenshot of a graph of two players' Brain Age test scores over time.

the following six Persuasive Technology (PT) principles proposed by Fogg [3] as a frame of reference.

Tunnelling. According to PT, tunnelling involves guiding users through a process or experience containing opportunities for persuasion. People are often most comfortable beginning and continuing a tunnelling experience when they can see results before committing more of their resources. Brain Age requires users to play at least one brain training game before playing other relaxing games, which are meant as incentives rather than training. Furthermore, Brain Age tunnels users into playing daily, since each game can only be played once per day. If users miss a day, there is no way to play twice the following day. Users lose both their chances to try to beat the top score and to get a new data point on their graph. Limiting the amount of play has the counterintuitive effect of encouraging users to play more to avoid losing out.

Additional levels of difficulty become available only as users either demonstrate sufficient skill, or play Brain Age for several days or weeks. Furthermore, by only making a few games available at first, the initial time commitment is minimal, but gradually increases as players get more emotionally involved and unlock more games. Brain Age's tunnelling persuades users to gradually invest more time and effort into playing and improving their cognitive abilities.

Conditioning. PT states that people can be conditioned to behave in a desired manner by offering rewards that encourage such behaviour. Users get a stamp on their in-game calendar for every day they play Brain Age. A larger stamp is awarded for completing several games that day. Users who play Brain Age over several days gain benefits: more training games, more challenging levels, a self-drawn daily stamp, and access to other secret functions. Users who top high scores are rewarded with special sounds and visualisations.

Suggestion. PT suggests that well-timed persuasive messages are most effective. Many factors contribute to determining the ideal moment for a suggestion, including the current time of day, location, activity, and state of mind. After players complete a game, Kawashima's avatar offers out-of-game techniques for improving brain cognition, such as memorising as many bus advertisements as possible in 30 seconds. Users are more likely to entertain the avatar's suggestions at this particular time since they will want to improve their cognitive abilities and Brain Age scores.

Self-Monitoring. PT claims that visible indicators of progress and current state can provide motivation for improvement. Brain Age provides this self-monitoring by maintaining the top 3 scores for each individual and across all players, on a per-game basis. These scores are displayed after each game. Furthermore, Brain Age also tracks players' performance over time and graphs this information after each game (see figure 1). These tools help users identify areas for improvement and provide motivation to continue playing in order to improve their performance.

Surveillance. PT asserts that people can be persuaded to perform certain actions by making others aware of these actions. Although it may seem a negative term, surveillance can be employed ethically, such that people may appreciate someone watching over and guiding them. When users play their first game of the day, Kawashima's avatar will either congratulate the

figure 2. Screenshot of Dr. Kawashima's avatar congratulating the player.

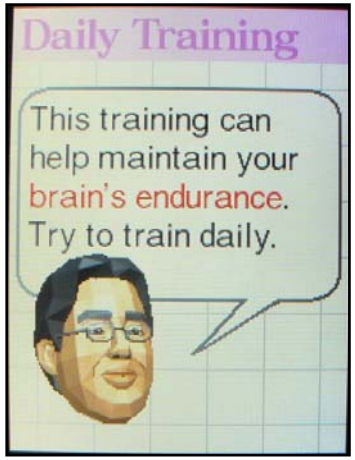

figure 3. Screenshot of Dr. Kawashima's avatar persuading users to play every day.

player for returning every day or express disappointment when a user has neglected their daily training. The avatar will also comment on a player's lengthy absence to other players. Players may be persuaded to maintain a daily regiment of brain training, knowing that the system is tracking their behaviour and will inform others of one's lack of training. Users may also compare their progress and scores to those of other players (see figure 1), and be persuaded to play and improve through social dynamics, such as competition and encouragement. Since users know that their progress can be easily observed by others, there are social incentives to play and compete as much as possible.

Social Cues. PT describes how technology can leverage social cues to increase persuasive power. In Brain Age, Kawashima's avatar first introduces himself as an authority on brain function, adding credibility to his advice. The avatar applauds daily play and expresses loneliness if a user forgets to play. The avatar also cheers when players improve their score (see figure 2), and expresses disappointment when they achieve a lower score. Players may feel compelled to play daily to impress the amicable avatar.

Humour, Fun, and Challenges. Gilleade et al. [7] suggest that affect can motivate gamers through a combination of guidance, challenge, and emotion. Brain Age leverages affect in several ways. Kawashima's avatar makes silly faces, uses silly wording, and gives hints on triggering amusing behaviour. Users are given access to fun non-training games after completing their daily training. Brain Age games are designed so that users will see progress in only a few days, yet room for improvement remains to maintain player interest.

Application to Security

We will now explore how the persuasive strategies in Brain Age may be repurposed to help people more easily and securely authenticate to computer systems. We focus on authentication because most users face the challenges of authenticating securely several times a day. However, we believe these strategies could be applied to security systems in general. We recognise that users invite Brain Age's persuasive experience by choosing to play. Since this is not true for security, we must be careful to avoid interfering with users' primary tasks, which computer security is intended to support.

Tunnelling. Whereas Brain Age encourages users to return to the game daily to continue improving their memory (see figure 3), no analogy exists for passwords. Users typically create a password, confirm it, and then later use it to log in. There is no support for users to practice remembering their password before it must be used. Users could have the option of performing memory-aid tasks, such as password rehearsal games [4], to help learn their new password. Also, the system could help users remember new passwords through scaffolding: gradually giving users more autonomy as they demonstrate that they have memorised their password by entering it in reasonable time with minimal errors. Such a system could also be tailored to help users train on multiple passwords and accounts, so that they memorise both the passwords and the accounts to which they belong.

While this system may be viewed as a hindrance to more advanced users, we envision it as a training tool for novices or those who voluntarily use it. However, the tension between usability and security is apparent in such an approach. Although increased password use

leads to better password memory, it also increases the opportunities for an attacker to gain knowledge of the passwords through malware such as keyloggers or by acquiring access to the password rehearsal game [4] that contains information about the user's passwords.

Conditioning. Brain Age provides conditioning through encouragement and incentives, such as unlocking new games. Typical password systems currently offer no rewards for the successful memorisation of strong passwords, other than allowing access to the given account and offering an increased hope that the password is safe from attackers. We propose that systems could offer incentives to users who have strong passwords and make few login errors. These incentives could include more account privileges, additional disk space, priority access to resources, additional functionality, and less frequent password reset requests. Any incentives must be carefully implemented so that attackers observing system behaviour cannot identify accounts with weak passwords to increase the efficiency of an attack.

Suggestion. Kawashima's avatar offers suggestions about activities players should incorporate into their daily life to develop better memory. A password system could similarly offer suggestions to help with password memorisation or the creation of stronger passwords. These suggestions could be made at an *opportune moment*: either a convenient time for the user or when user performance indicates that this user could remember a stronger password. To help with memorisation, the system may suggest that users take advantage of available password rehearsal games [4] or offer advice on how to create secure but memorable passwords. We have previously used suggestion to influence users to select more secure passwords [5].

Self-Monitoring. A password system could monitor information on a per-user basis and present a summary after login. Potential metrics include time since previous login, average number of incorrect login attempts, average time taken to log in, estimated time needed to crack the password, and others. These allow users to gauge how well they are remembering their password and evaluate the security of their current password. Although some password systems already provide such information, it could be presented in a format similar to Brain Age's performance graphs and top 3 lists. This may encourage users to engage with the system and try to beat their records. However, these measures should consider both password strength and user performance, to discourage users from selecting easy-to-remember passwords simply to achieve better results. Strength meters are an example of self-monitoring password strength, but are currently used only during password creation.

Surveillance. Players of Brain Age are subject to surveillance, both by the system and other players who may see performance scores and responses in shared activities. Password systems cannot risk publicising any information related to a user's password, but other types of surveillance are available. Many security administrators use special tools to test passwords' strength without viewing users' actual passwords. If users were aware and reminded of such practices, they may be motivated to choose more secure passwords.

Social Cues. Kawashima's avatar persuades users to play Brain Age by being friendly, knowledgeable, and

authoritative. Through a similar use of language, users may be open to suggestions on improving their passwords, or be persuaded to practice their password. Careful user interface design for new password systems can positively impact user acceptance and trust, similar to the role of Kawashima's avatar as a concerned expert. Observing social conventions, such as greeting users by name, can make interactions more pleasant.

Humour, Fun, and Challenges. Although considered challenging by many, passwords are traditionally not considered fun or humorous. Yet, passwords are hardly worse than Brain Age activities, such as memorising words and numbers, or performing arithmetic calculations. By presenting a game-like interface, it may be possible to position passwords as fun and engaging challenges that users *want* to perform, rather than bothersome barriers. A system may also offer multiple authentication schemes and select a password scheme best suited to each user's skill set (determined through regular system use or some special test). Changing passwords and mechanisms could be presented as a gaming challenge, encouraging users to engage in secure behaviour, without making it tedious.

Conclusion

We examined Brain Age for ways to help users remember secure text passwords. Instead, we found that Brain Age compelled users to repeatedly perform brain training activities that would otherwise become tiresome. We described the influential design elements of Brain Age using Persuasive Technology principles, and explored how they may ease the burden of computer security tasks, such as authentication. The next step is to prototype these ideas and empirically test their effectiveness in lab and field studies.

Ideally, users should not need to concern themselves with computer security. However, even the most intelligent security systems will sometimes misinterpret users' intentions, and will always be targeted by attackers. Thus, users will need to communicate with security systems to describe their intent or be alerted to potential threats. We believe computer security can be improved by establishing a partnership with users through simpler and more engaging dialog.

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