Neeuro Presents

IMPROVING COGNITIVE HEALTH WITH GAMIFICATION AND EEG

2022/2023 White Paper

RESEARCH ON COGNITIVE TRAINING

The brain has been found to have the ability to control many aspects of functional thinking and this includes planning, organising, making rational decisions, remembering tasks and so much more. Our performance in these cognitive abilities can indicate how well we do our everyday tasks and whether we can live independently.

However, progressive changes occur in both physical and mental aspects as a person gets older [1-2] with cognitive decline occurring as early as in the thirties [94]. Certain parts of the brain shrink and can affect learning and other complex mental activities [95] the synapse structure (communication between neurons) may no longer be as effective [96], and the blood flow in the brain may decrease or be slower [97].

Nevertheless, slowing or preventing the onset of cognitive decline is possible by adopting a healthy lifestyle and cognitive interventions such as mental stimulation and cognitive training [98]. This is also supported by the National Institute of Health (NIH) which conducted a meta-study based on 250 high-quality publications and found cognitive training to be a highly effective protective factor in preventing cognitive decline [29].

Cognitive training has demonstrated benefits across all age groups, from young children to the elderly [33-44]. It has been shown to play a positive role in improving fluid and crystallised intelligence [3-7] while also being sustainable [8-10] and transferable to daily functions [11-26]. At the same time, it has also been shown to be an effective non-pharmaceutical solution for people experiencing mental health issues [45-64].

With medical advancements, functional Magnetic Resonance Imaging (fMRI) and neuroimaging techniques have allowed researchers to observe the direct impacts cognitive training has on specific areas of the brain. These advancements have also given rise to the field of neuroplasticity (how malleable the brain is adapting to new stimulation), giving credence to the notion that our lives can be improved through training and stimulation of our brains [30-32]. Overall, the evidence found for the effectiveness of cognitive training has a strong scientific basis for combating cognitive decline.

GAMES FOR THE BRAIN

Engaging in stimulating and purposeful activities is crucial for people to improve their quality of life. For those who have physical constraints or limited activity opportunities, digital games can offer a means for them to continue being engaged and mentally active. Driven by the National Science Foundation (NSF), neuroscientists and entertainment experts have initiated collaborations [68] to develop digital games to get a deeper understanding of brain functions and to provide new tools to boost attention and well-being. An example would be computer-based cognitive training which is found to improve memory and performance of everyday tasks for seniors [66-67].

Moving forward, the health and technology industry is on its way to bringing more therapeutic games into the market [69], potentially creating a larger impact on those pursuing cognitive health and wellness.

EEG-BASED COGNITIVE TRAINING

The use of electroencephalogram (EEG) by researchers in digital games is a recent advancement in the field of neuroscience. Numerous studies have investigated the impact of EEG in digital games and have found it to be effective in improving participants' cognitive abilities [1]. There are many associations between EEG biomarkers and cognitive functioning. For instance, there is a high correlation between the activation of theta brain wave activity (4–8 Hz) with one's working memory [70-71] while beta brain wave activity (14–30 Hz) is generally associated with one's attention level [72-73]. For tasks that require visuospatial abilities, participants who activate their alpha brain wave activity (9 -13 Hz) performed better on mental rotations after going through EEG-based cognitive training [77]. Engaging individuals in tasks that induce these brain waves can help to dramatically improve their cognitive performance [75].

There may be some doubts concerning the possibility of diminishing cognitive gains during training due to cognitive overload, but this can be overcome with the use of an adaptive real-time monitoring system based on EEG biomarkers. By doing so, mental fatigue can be measured and effectively controlled hence allowing for participants to have a customised experience during gameplay to perform their best [74].

All in all, the use of EEG technology in facilitating cognitive training provides real-time brain wave measurements and gives accurate indications of a participant's mental state. The adaptive component found in the cognitive training programme also enhances the experience hence effectively reaping maximum benefits.

NEEURO MEMORIE GAMES

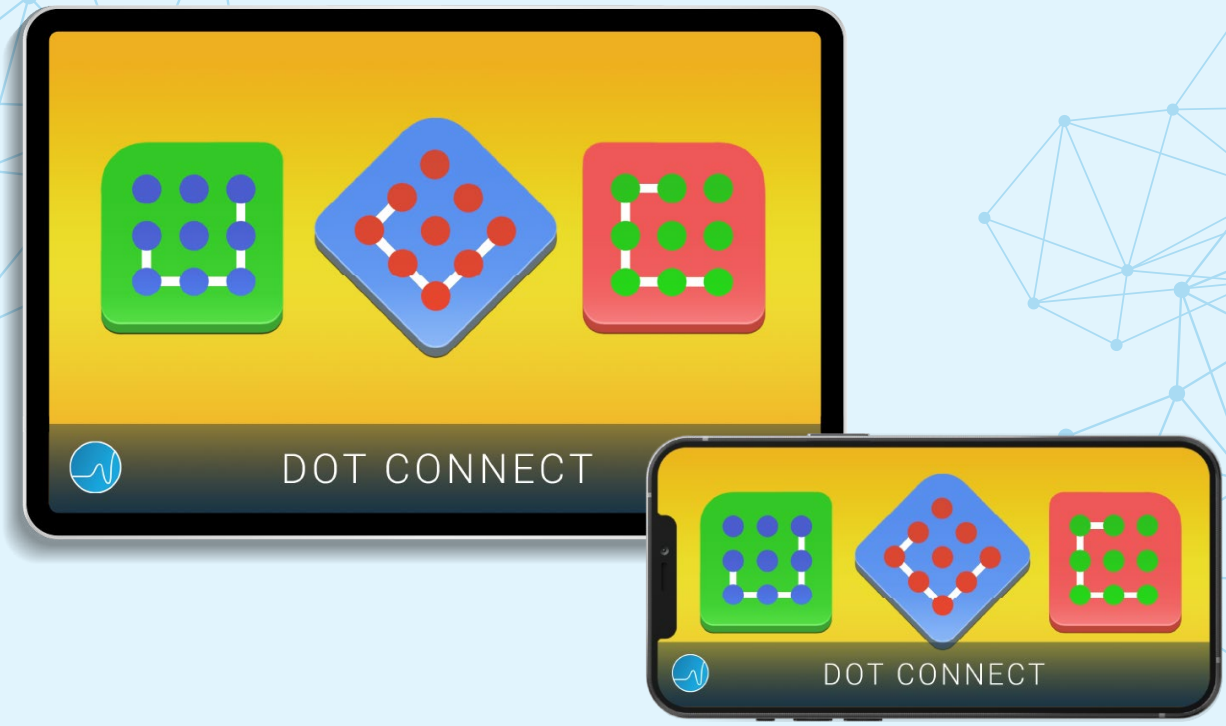
Neeuro's Memorie mobile application equipped with Neeuro's EEG headband, SenzeBand 2 offers a unique solution for brain training, which can be done in a fun manner, anytime and anywhere.

SUSHI RECALL

Sushi Recall is a fun version of n-back task that is most commonly used in cognitive assessments to measure working memory [84]. Using the n-back task has also been shown to increase both brain thickness and surface areas which indicates better performance in complex cognitive tasks such as language comprehension, learning, and reasoning [85].

During gameplay, the player has to remember a variety of sushi types supplied by a conveyor belt. As one or more sushi disappears, the player has to recall the last sushi. The number of sushi disappearing will progressively increase to make the task more difficult as the player moves to the next level. Hence, for players to succeed in each level, they will need to continuously activate and manipulate information from their working memory.

The objective of sushi recall is to essentially allow players to practice temporarily retaining pieces of information that can be vital to conduct a variety of everyday tasks. This ability to hold information allows for better everyday reasoning and decision making such as dialling a new telephone number or recalling where you might have placed your items such as a book or a mobile phone.



DOT CONNECT

Dot Connect is inspired by mental rotation tasks [86] where the player will have to activate their spatial abilities by identifying a given 2D line segment after which they will have to replicate, flip and rotate a separate line segment as per instructions from the game. While seldom discussed compared to short-term memory loss when it comes to cognitive decline, our spatial abilities are an important subset of our general intelligence [87]. These cognitive skills are pervasive in various everyday tasks, such as reading maps, driving [88], and during mathematical performance [89].

In the beginner levels of Dot Connect, the player will only need to mentally rotate the board in 90 and 180 degrees clockwise or anticlockwise. A colour guide is provided in the earlier stages to familiarise players with the rules of the game, after which it will be removed as players progress into later stages and get more competent. Additionally, the sensors from our Senzeband will allow evaluation of players' visual spatial attention and focus [90] hence providing accurate measurements in tracking their overall progress.

MINDCOPTER

Mind Copter leverages studies that show the association of EEG biomarkers to facilitate attention training [72, 73]. The Senzeband captures real-time measurement of the player's attention level which not only provides an extra dimension to game scoring but also tailors an adaptive training programme to improve their selective and divided attention capabilities. These cognitive skills are important to manage distraction so that unimportant details can be tuned out and one can finally focus on what matters [91]. This will also be useful to help concentration during a task or event for a prolonged period.

The player will take on the role of a pilot and will need to activate their attention to airborne the helicopter and perform rescue missions for stranded survivors. The player will need to sustain their attention to drop off care packages for survivors and to wilfully release attention so that the helicopter can descend and rescue them. As the game progresses, the helicopter gets 'heavier' and harder to control with more obstacles introduced.

PYRAMID SOLITAIRE

Pyramid Solitaire is a modified version of the classic Solitaire game in which gameplay has been demonstrated to improve cognitive functions such as short-term memory [78]. Leveraging on the concept of neuroplasticity, when players have to frequently activate their working memory to recall the value of the cards [79], the brain will create or strengthen new neural pathways and hence have the potential to remain robust even in the cases of Alzheimer's Disease (AD) [82]. The game requires players to match two cards that will add up to the value of 13. Players will also activate their decision-making skills as they decide which strategy or pathway to take first, depending on the cards they have on hand and the cards available in the pyramid. With the right strategical decision, they will not chance upon a situation where they unlock a tier that has no other cards to match. Unlike classic pyramid Solitaire where unused cards are promptly disposed of, Pyramid Solitaire allows players to stash their cards for later use. However, cards are faced downwards so they will need to remember the values of the cards that are stowed away. This requires memory work and any wrong guesses will lead to a score penalty.

MULTITASKMASTER

Multitasker Master was created on ideas of task-switching paradigms [92] and the drive towards building cognitive flexibility that helps people pursue complex tasks such as efficient problem-solving and creativity [93].

The game is uniquely split into two screens with tasks to complete on both sides. Points are granted when tasks are completed screen by screen. This means the player has to complete screen 1, then move on to screen 2 then back to screen 1. The tasks to complete are different in nature hence encouraging the player to use various cognitive functions quickly and efficiently. For example, screen 1 could be displaying a mathematical sum that requires mental calculation while screen 2 displays a pattern recognition problem that requires the player to identify and analyse patterns between figures. As the player progresses, the time given for the player to solve questions on each screen reduces.

CONCLUSION

We are in a world of rapid information growth and experiencing the age of attention crisis. With unprecedentedly longer life spans, people are experiencing a cognitive decline earlier than expected. These are the factors that place a great challenge for us to maintain cognitive fitness throughout life. To enhance our cognitive well-being and prevent cognitive decline, it's important to engage in ample of mental exercises in addition to a healthy lifestyle.

The effectiveness of brain training has been advocated by decades of scientific research. While mobile applications and computer games become increasingly inevitable in today's world, so is the convergence of health, technology and games. Mobile games paired with lightweight EEG sensors make it possible to facilitate closed-loop cognitive training in daily life, offering adaptive, handy and powerful training programme for effective brain exercise for everyone, anytime and anywhere.

ABOUT NEEURO

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Neeuro is a global company that specialises in utilising Brain-Computer Interface technology to maximise the potential of users' neurological agility and fitness. Since its inception in 2013, Neeuro's extensive portfolio and an array of digital therapeutic and brain fitness solutions are backed by clinically validated research by A*STAR, an institution widely known as being at the forefront of Singapore's research endeavours.

Its core technology, NeeuroOS, is a platform that empowers healthcare professionals, researchers, and third-party developers with an Artificial Intelligence (AI) driven ability to analyse the brain signals of users, measuring mental states including but not limited to attention, relaxation, mental workload, and fatigue. Neeuro's holistic offerings numerous potential avenues to explore complementary mental health options for children with ADHD, patients with stroke, cognitive rehabilitation, and many other neurological challenges.

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