## Unlocking the potential of youths and adults

## to acquire and deploy digital skills

Summary of a study conducted to develop and test a cognitive augmentation training game designed to assist youths and adults to enhance their information processing skills so that they can more effectively acquire and deploy essential digital skills.

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**Background**

At the World Economic Forum in Davos, Canadian Prime Minister Justin Trudeau suggested that in order to create growth and prosperity in the context of the fourth Industrial Revolution, Canadians need to rely more on what they have between their ears than what they have under their feet (Trudeau, 2016.a). In another instance, Prime Minister Trudeau also argued that in order to promote innovations and a better future for all, we need to bridge together our creative abilities and the various levers and multipliers of technology (Trudeau, 2016.b). This vision for creating growth and prosperity for all presupposes that people are equipped with the foundational skills to fully benefit from digital technology. Unfortunately, a significant proportion of youths and adults do not have the necessary level of information processing skills to take full advantage of digital technology, especially those belonging to the most vulnerable groups. This cognitive skills gap is a new form of digital divide that must be bridged before such a vision of economic growth and development can become achievable.

Digital technology has become a key driver for economic prosperity, and a digitally-skilled workforce is now a prerequisite for benefiting from the opportunities offered by the digital economy. Prosperity from the digital economy will depend not only on specialists and advanced users of digital technology, but also on the contributions of all workers in general. Almost every sector of the economy needs workers who have the essential digital skills. A recent study conducted for the Office of Literacy and Essential Skills (OLES) revealed that workers need to have complex cognitive and metacognitive skills, over and above the basic skills necessary for operating computers, in order to cope with the increased demands for processing large amount of information rapidly, effectively and efficiently. Information processing skills were therefore embedded in the Essential Digital Skills Framework for the Canadian Workplace.

Because of the rapidity with which the flow of information takes place, a person needs to have highly-developed cognitive controls to be able to cope with information processing demands effectively and efficiently. As a consequence, individuals who do not have these necessary cognitive controls may not fully benefit from digital technologies and could be left behind.

There is a considerable body of knowledge that has been accumulated on cognitive controls through empirical research, and various cognitive control dimensions have been identified. The field-dependent/field-independent (FD/FI) cognitive control is the most influential construct and has been extensively researched. This psychological construct relates to a global versus an analytical way of perceiving, and entails the ability to perceive items without being influenced by the background. Research evidence suggests that field-independent individuals process information more effectively and efficiently than their field-dependent counterparts.

Only a few decades ago, we were limited in our efforts to help people to improve their cognitive information processing skills because of a constraining belief that the cognitive control was fixed and could be modified. However, revolutionary developments in neuroplasticity and cognitive modifiability have paved the way for innovative approaches for developing and enhancing human cognitive controls. A joint study entitled “Unlocking the potential of youths and adults to acquire and deploy digital skills” was conducted to address this issue. The purpose of the study was to develop and implement a serious video game to enable youths and adults to enhance their level of cognitive control (level of field-independence) so that they can more effectively acquire and deploy the essential digital skills.

**Study Brief**

Phase 1 involved a literature review to identify innovative approaches in current use for the development and assessment of analytical skills, based on recent brain research on neuroplasticity and cognitive modifiability. Research evidence suggests that field-independent individuals process information more effectively and efficiently than their field-dependent counterparts. Field-independent individuals can: restructure information for better comprehension and retention; create missing information; focus on relevant information; pay attention to details; deploy more effective and efficient information processing strategies; identify distinctive features in complex environments easily; and solve problems quickly. Field-independent individuals also deploy information-processing strategies that contribute to successful learning and performance. Highly integrated technology-based environments debilitate field-dependent users because of their limitation in tolerating the imposed information-processing load. The extent of this debilitation is proportional to the level of technology integration in the environment.

Drawing from this literature review and lessons learned, Competences R & D Inc. developed prototypical material for augmenting and assessing analytical/information-processing skills during Phase 2. The field-dependent/field-independent (FD/FI) construct is the most influential cognitive control having profound influences on human performance. Ever since the construct was discovered during World War II, thousands of studies have been conducted to fully understand the construct, to examine its education and training implications, and to investigate its applications for learners’ empowerment. The applied field has not fully benefited from these investigations because the focus was on trying to improve human performance by changing environments that were external to learners. Consequently, the potential for improvement was extremely limited. Because of this challenge, there was a period of decreased interest in the FD/FI cognitive control. However, there has been a renewed interest for this cognitive control because it has now been integrated into mainstream cognitive psychology and neuroscience. This paradigm shift has paved the way for innovative strategies to assist people to enhance their cognitive control by targeting conditions that are internal to the individuals.

Some researchers still abide by the long-held belief that the FD/FI cognitive is fixed, stable over time, and cannot be modified. Others posit that cognitive style is malleable and can be altered. The available opinion-based information on the malleability of cognitive style is inconsistent and contradictory. Recent scholarly works are establishing strong links between cognitive style and brain plasticity in the educational neuroscience paradigm, which views cognitive style as malleable and modifiable through learning and experiences.

The design and development of several of the recent brain training interventions developed for commercialization were patterned after a variety of standard psychological tests. The assumption made is that an individual will acquire a particular cognitive skill if s/he is asked to perform small training tasks that are highly similar in content and structure with tests used on psychological assessment scales. The training design for NeuroLudus was patterned after the Hidden Figures Test (HFT). The HFT is used to assess the cognitive control field-dependence (FD) and field-independence (FI). The FD/FI construct relates to a global versus an analytical way of processing information. The HFT positions an individual on the FD/FI continuum. The HFT presents test takers with 5 simple shapes at the top of a complex figure. Test takers are required to identify the one simple shape hidden in the complex figure and to provide their responses in the format of a multiple-choice questionnaire. The FI individuals are more successful in disembedding the simple figure from the complex figures. The FD persons, on the other hand, are less successful in performing that task. Research has shown that the HFT is a valid and reliable instrument for measuring the FD/FI cognitive control dimension. Individuals scoring 18 to 32 points on the HFT are classified as field-independent. Those scoring 17 points or lower are classified as field-dependent.

NeuroLudus was designed to match the performance requirements of the HFT. The HFT was integrated into NeuroLudus under a licensing agreement with the Educational Testing Service, as pre-test and post-tests to allow players to monitor and assess their progress in analytical/information-processing skills that can be attributed to playing the game. NeuroLudus was designed and developed on the basis of sound learning theories, a mastery-learning model, and a cognitive apprenticeship model.

The NeuroLudus game structure consists of three game cycles and each includes six different game plays: 1. Drag and Drop; 2. Click and draw; 3. Flip horizontally, click and draw; 4. Flip vertically, click and draw; 5. Drag, rotate and drop; 6. Rotate, click and draw. Each game play, in these three game cycles, has five levels. The levels are based on the number of distracting lines presented in a complex figure (varying from five to twenty-five) and the number of simple shapes presented in each problem solving activity (varying from one to five). Therefore, the NeuroLudus hierarchical game structure adds up to a total of 90 levels. The mental process used in the HFT is similar to the first game play in NeuroLudus: Drag and drop. The five additional gameplays embedded within NeuroLudus include game plays that are far more challenging than the mental efforts required for taking the HFT test. Therefore, even people scoring high on the HFT are still likely to benefit from playing NeuroLudus. NeuroLudus consists of 3,060 problem-solving exercises stored in a database. The problem-solving tasks are presented to players according to a very specific algorithm related to game cycles, gameplays, number of distracting lines included in a complex shape, and the number of simple shapes presented to players.

In Phase 3 the prototypical material was formatively evaluated by typical learners, using one-to-one and small group formative evaluation methodologies, in order to identify and remove any errors and flaws that could affect its effectiveness. The revised prototype was reengineered and digitized as a serious video game during Phase 4. The prototype video game was evaluated by typical users to improve its learnability and usability. A web portal was developed for hosting the game and the supporting information management systems. A statistical package was also developed and embedded into NeuroLudus to collect learning analytics during the field test. Specific source code has been built into the NeuroLudus apps for collecting detailed information on players’ achievement, play time and players’ engagement. NeuroLudus has a database and information management tool to capture, collect, record and generate this information. NeuroLudus does not collect any demographics or other personal information from players.

A promotion campaign deploying the use of multiple communication strategies was launched in Phase 5 to promote the game to youths and adults. An animated instructional video demonstration and a user manual were developed to familiarize players with the various game plays. In Phase 6 the game was field-tested. The final Phase 7 consisted of the dissemination of the study results to key stakeholders.

**Study Results**

Forty-five percent of the registered players completed the Hidden Figures Test used as pre-test.

It is noteworthy that 80% of the players who took the pre-test were classified as FD. The average test score of these players on the HFT was 8.5, the maximum score being 32. The remaining 20% of the players were classified as FI, with an average test score of 26.5.

It is noteworthy that the mean post-test scores of the FD players jumped from 8.6 to 20, 23 and 20 points for post-tests 1, 2 and 3 respectively. The FI players also showed improvement by jumping from 24 to 26, 31 and 32 points for post-test 1, 2 and 3 respectively. Results indicated that NeuroLudus training helped to narrow the difference in performance on the HFT between FD and FI players. Results of post-tests 1 and 2 seemed to indicate a positive relationship between amount of time spent playing NeuroLudus and performance improvement on the HFT for both FD and FI players.

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| Table 1. Mean pre-test and post-test scores of FD and FI players on the Hidden Figures Test ( Max. score 32) | | |
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| Tests | FD | FI |
| Pre-Test | 8.6 | 24 |
| Post-Test 1 | 21 | 26 |
| Post-Test 2 | 26 | 31 |
| Post-Test 3 | 21 | 32 |

The average post-test score of the FD players who had completed the first cycle of the game and took the post-test 1 was 20.75, resulting in a jump of 12.25 points from the pre-test score. Sixty-nine per cent of these players changed their cognitive control classification from FD to FI on the basis of their post-test 1 scores. All FD players who had experienced a transformation to FI by game cycle 1, and also completed game cycle 2 and post-test 2, maintain their high scores and their acquired FI classification. Players who maintained the FD classification through game cycles 1 and 2 experienced a transformation to FI in game cycle 3, indicating that some individuals need more training time to enhance their cognitive control. Results indicated that on average it took 12 hours of playtime for the FD players to change their cognitive control dimension from FD to FI.

The average score of the FI players on post-test 1 was 21 points. All except 2 of the FI players maintained their FI classification with a mean post-test 1 score of 30 on the HFT, making a gain of 6.25 points. A debriefing of two players who slid from FI to FD revealed that they took the post-test after playing NeuroLudus for a long period of time. They believed that they were too exhausted to do well on the post-test.

A survey of NeuroLudus players indicated that the great majority of the players did not feel frustrated, irritated, pressured, annoyed or bored while playing the game. They also indicated that playing NeuroLudus did not put them in a bad mood and they did not find it tiresome. In general, the players were satisfied with their gaming experience. The great majority of the players did not feel bad, guilty, weary or disoriented while playing NeuroLudus. They also indicated that they had no regret spending time playing NeuroLudus, and they did not believe that it was a waste of their time.

**Conclusions**

The following conclusions were drawn from the results and findings of this project. These are preliminary conclusions given that several players are still playing NeuroLudus and have reached various levels and game plays. As the registered players continue to play the game at their own rate; new players are signing up to play NeuroLudus on a daily basis. When new data set becomes available from additional players, the results obtained will be analyzed and the findings and conclusions updated and disseminated at critical intervals.

* The FD/FI cognitive control, which has a strong effect on information processing, can be modified by appropriate training.
* Both FD and FI individuals benefit from cognitive augmentation training;
* To fully benefit from cognitive augmentation training, people need to have determination and be prepared to invest a considerable amount of time and effort in the training activities so that they can reach the required level of fluency. An average of 12 hours of playtime is necessary for an FD player to experience a shift to an FI cognitive control dimension;
* NeuroLudus is bug-free and has all the functionality to achieve the training objectives. However, additional development work is necessary to enhance the attractiveness of NeuroLudus, to embellish the motivational and reward system features of the game in order to better capture and maintain players’ engagement and persistence, as well as to improve the average time taken to complete the game.
* Players’ engagement to NeuroLudus was substantially improved by including the training as a course requirement and awarding credits for their participation and completion of the training activities.
* A pre-test can be a deterrent to players’ engagement in cognitive augmentation brain training activities. Only 45 per cent of NeuroLudus registered players took the pretest and proceeded to the various game plays.
* Although NeuroLudus was designed as a self-instructional training package, some individuals from the lower end of the FD/FI continuum may need the assistance of a mediator to guide and assist them in their cognitive transformation process.
* With the exponential increase in new apps being developed and published every day, it is becoming extremely difficult for an app to be discovered by potential users without an intensive and sustained digital marketing campaign.
* Some scientists have severely criticized the commercialization of cognitive augmentation training games, and have claimed that there is insufficient evidence supporting their effectiveness. It took several years for scientists to come to an agreement that the brain is plastic and modifiable. Valuable time was lost in trying to change deep-rooted convictions, rather than focussing efforts on investigating how brain plasticity can be applied to empower human beings. Now that the legitimacy of neuroplasticity has been established, the controversy has shifted to the validity of brain training exercises for enhancing essential cognitive skills. Instead of wasting precious time in contesting the legitimacy of brain training, scientists should pull together to determine how to design and develop the optimal brain training exercises. Brain training is in its infancy. Like all innovations, it is conditioned to a period of incremental and continuous improvement, informed by research and development. Brain training research and development should therefore be encouraged and financially supported.

**Study Team**

France Boutin, Ph. D., Professor, Université du Québec à Montréal (UQAM), Project Director and lead researcher. Designed, developed and field-tested NeuroLudus.

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The team would like to acknowledge the contribution of:

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To get FREE access the NeuroLudus online or to download the IOS and Android apps, Go to <http://www.neuroludus.com>

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