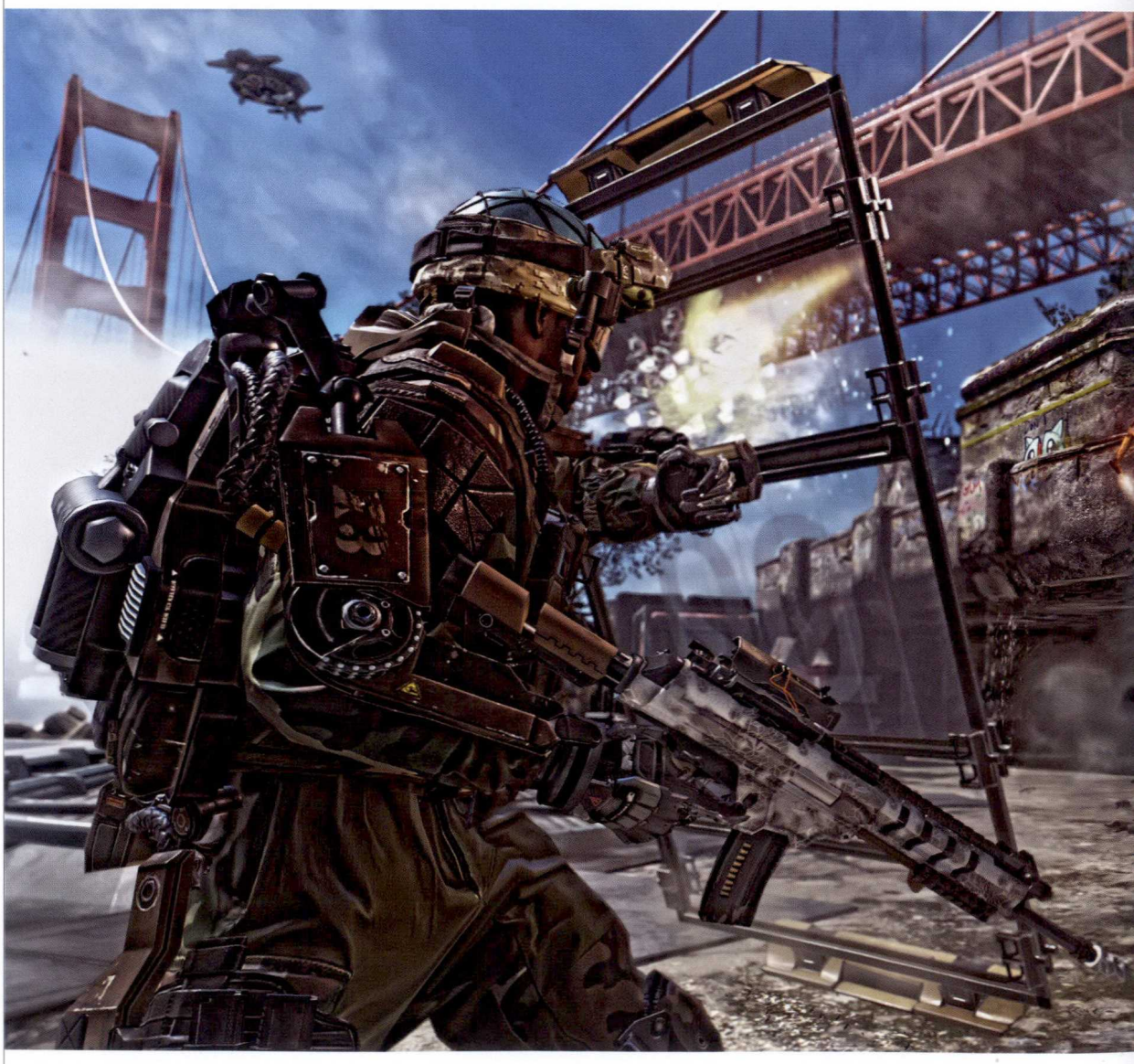
Shoot-em-ups Good for the Brain?

Are videogames more effective at improving brain function than dedicated cognitive training?



Call of Duty: Advanced Warfare, shown here, is one of the most popular FPS games. The screengrab on p. 15 shows the strategy game Civilization

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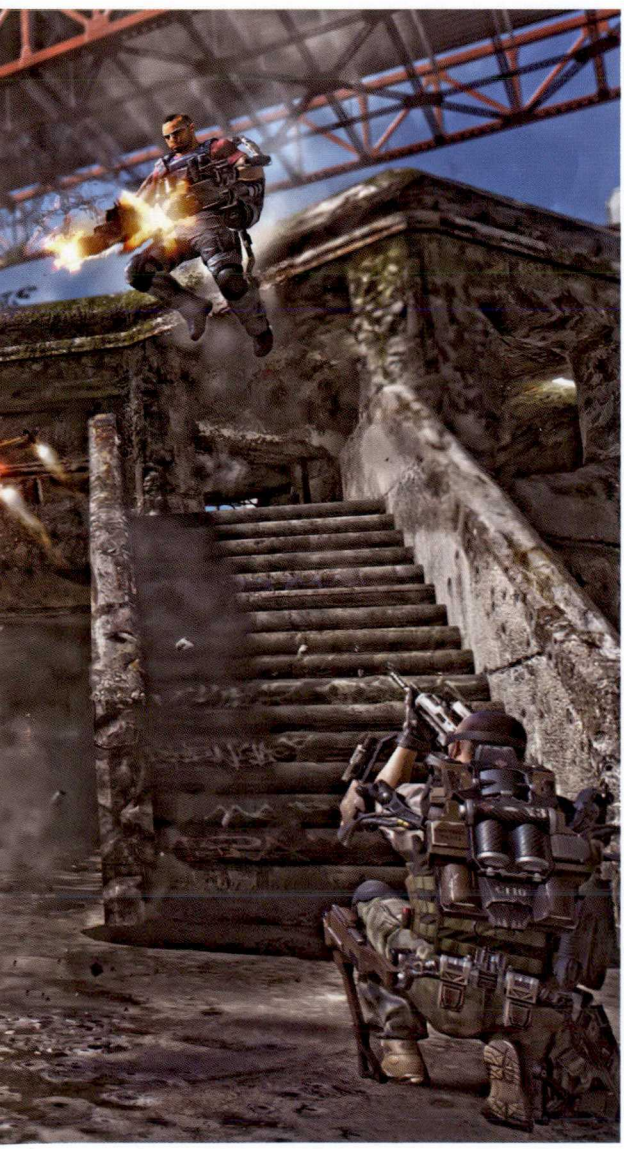
In recent years, we have seen rapid growth in methods purporting to improve our minds. It is a response to our latent desire – often fueled by films such as Luc Besson's "Lucy" starring Scarlett Johansson – to keep developing the function of our minds and the brains that contain them. The simplest way of achieving this, requiring the least amount of effort, is taking brain-improving pills, especially if they start acting straight away and have a lasting effect; unfortunately this carries the greatest risk of side effects.



Such substances are already in use – even if the results aren't as spectacular as Hollywood blockbusters would have us believe – and new, safer and more effective treatments are under development. Researchers are also studying other "intermediate therapies," such as stimulating the brain with electrical waves, magnetic fields or EEG neurofeedback.

During the last decade, the use of digital media for brain training has been attracting growing interest. We are seeing an explosion of digital mental exercises aiming to stimulate natural mechanisms of neural tissue plasticity with a wide range of approaches. Neuroplasticity – the brain's ability to "reprogram" itself following injury or certain experiences – has been confirmed by many studies. For example, some people who sustain brain damage are able to recover lost function by redirecting stimuli to a different area of the brain. A renowned study compared hippocampus size in drivers of London's black cabs and buses, revealing they are larger in the former. And it's no wonder – taxi drivers undergo rigorous training and testing on navigating London's complicated street network before they gain their license, and this involves high activity in the hippocampus.

These and many other research results leave us in no doubt: the brain is a flexible organ able to adapt throughout our lives. This means that by taking appropriate action we can not only delay the negative effects of ageing, but also improve our abilities. This raises the question: what's the best way of achieving this?

Brain school

It seemed for a while that the answer would be cognitive training. A classic example is the n-back task which improves working memory – the ability to store and process information. It involves showing the subject a sequence of stimuli (for example letters) and asking them to indicate when the stimulus matches the one from a given number of steps earlier in the sequence (the number of steps which need to be remembered indicates the difficulty level of the exercise – the more steps, the more difficult they are to remember). The training became popular following the famous publication by Susanne Jaeggi et al. from 2003, showing that people who used dual-task paradigm exercises (combining different types of stimuli, such as auditory and visual) and showed improvement as a result performed better in tasks measuring fluid intelligence. Unfortunately the great hopes invested in this are likely to have been in vain. Even though the results of this original study have been repeated by other research teams, the majority of scientists question whether it's really possible to improve such a highly complex trait as intelligence by using a single, very specific exercise.

Most researchers tend to agree that the typical outcome of such training is near transfer – an improve-

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ment in the subject's ability to perform the specific tasks included in the exercise, or very similar ones. Of course the majority of people using such exercises actually hope to achieve changes which are more far-reaching and less obvious. We refer to this as far transfer – an improvement of function in skills which were not actually exercised as part of the task.

And here is where videogames come in. It turns out that certain pastimes also result in far transfer of information, with the added bonus of being fun to take part in. We could draw an analogy to various types of physical exercise. The desire to reach a certain effect, such as improving physical condition by performing repetitive, precisely targeted tasks on a treadmill, is similar to cognitive training, while activities such as playing basketball or football, focusing on dynamic social interactions, are more like playing videogames.

The relationship between playing videogames and mental skills was first described in a paper published by Green and Bavelier in the prestigious weekly *Nature* in 2003. The article shows that people who play action games perform significantly better in tasks involving visual attention. Over a hundred papers have been published since then, with the great majority showing that playing videogames engages and improves simple perception skills and many other higher mental functions. Additionally, it has been noted that gamers exhibit certain changes in brain structure and function, which has been interpreted to support the hypothesis that playing videogames stimulates neuroplasticity. Many researchers are convinced that the challenges faced by gamers – learning new skills, performing several tasks at the same time, logical thinking and fast reactions to changing stimuli – stimulate the nervous system. It also seems that the way in which these activities are performed in videogames (e.g. context learning, immediate improvement, carefully selected difficulty level) further enhances their effectiveness. Since videogames are designed specifically to provide as much entertainment as possible and encourage maximum engagement, gamers don't experience the kind of fatigue commonly found when performing classic cognitive exercises.

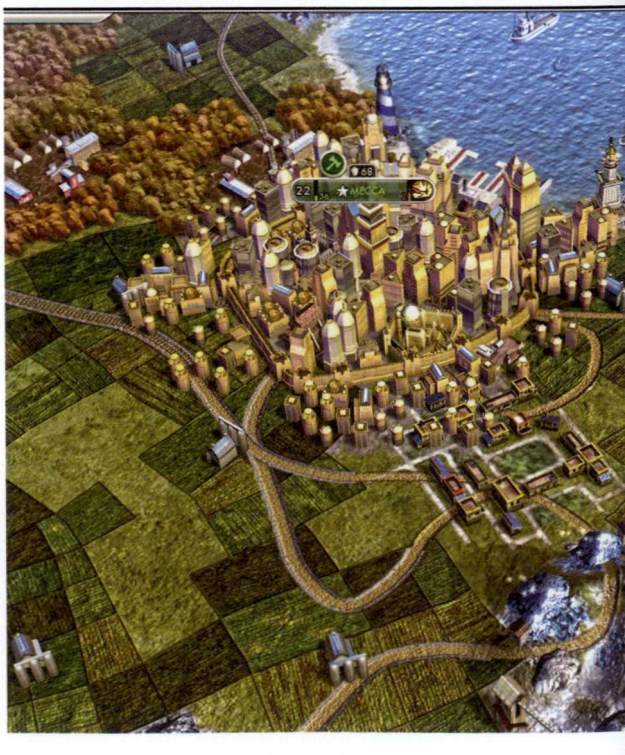
However, it turns out that not all games bring equal benefits: some have no effect, or may actually contribute to the worsening of certain cognitive functions.

Malingering minds

To start with, researchers focused on action games, a diverse genre including real-time strategy (RTS) and first-person shooter (FPS) games. From a psychological perspective, action games have a lot in common: they all involve several cognitive processes, from basic perception functions such as the ability to monitor several fast-moving objects at once, maintaining attention and a sufficient level of alertness, to more complex aspects of cognitive function such as the ability to rapidly refresh information, switching between different tasks and forward planning. Some of the results which have been repeated many times include those indicating that players of action games excel at perception tasks such as noticing contrasts and spatial perception in comparison to non-gamers. They also have a higher visual attention expressed mainly as the ability to follow several moving objects at once, including those in peripheral vision.

However, some of the studies revealed no improvement in cognitive skills. This was especially notable when studying games which weren't strategy-based or FPS, but it was also observed in these action games. Additionally, one of the studies conducted among students revealed that the total time spent gaming is correlated with lowered attention during school hours. It should be noted that this particular study didn't note the type of games played by the students and treated all the categories the same way.

And this clearly misses the point; research is increasingly showing that not all kinds of games have the same (positive) effect on the cognitive system. This should come as no surprise, since improvements to cognitive function as a result of playing videogames are a side effect – games are not designed so that their content, action or mechanics have a positive effect on our minds, and this aspect of gaming has been discovered quite by accident. This makes the type of game played even more important. Studies comparing the abilities of players of strategy and FPS games indicate different improvement profiles closely tied with specific game



requirements. Strategy games such as Star-Craft involve rapid switching between modes of play, which translates into significant improvement in performing tasks engaging executive functions, in particular switching. In turn, FPS such as Call of Duty pose major challenges to the perception system, and players regularly significantly outperform others in terms of noticing details in the visual field, including peripherally.

We have increasing amounts of data indicating that cognitive improvements are closely tied to the requirements of the given game. This is known as the common demand hypothesis, which is in contrast to the learning to learn hypothesis which predates it; the latter aims to explain improvements shown as a result of playing videogames as a general improvement in intellectual function.

Research caution

Since commercial games are not created with the aim of improving cognitive function, their design isn't based on neuroscience and psychology research into the plasticity of cognitive function and the neurophysiological mechanisms underlying it. In 2013, *Nature* published a cover story written by Californian researchers led by Prof. Adam Gazzaley describing attempts to hybridize cognitive training with videogames. The resulting game, NeuroRacer, turned out to have been a great hit: after playing one of the versions (closely related to classic videogames), older adults were found to show improvements in their ability to complete control cognitive tasks, and their brain activity patterns were similar to those of younger people. Unfortunately NeuroRacer's creators are not launching the game to the public, saying they need to conduct further research. However, a company co-founded by one of the authors is working on creating and launching a commercial version of the hybrid.

The fact that researchers are holding back from releasing games until their effectiveness has been demonstrated is encouraging, since it means they are taking the task seriously. Meanwhile many brain games and smart games are being published online, with their creators usually accompanying them with blurb proudly proclaiming their confirmed effectiveness. Yet this couldn't be further from the truth: the majority of the products have never been tested, while those that have (for example as part of Adrian Owen's 2010 study also published in *Nature*) aren't worth the pixels they are published on – or, more precisely, the only improvements seen after playing such games is the ability to play precisely those games.

The problem with using videogames – both those commercially available and those designed to improve cognitive function – is that we are only at the threshold of discovering their real effect on our brains. As such, in spite of promising but frequently contradictory and not fully explained results, we should exercise caution in drawing conclusions and preparing recommendations for individual people.

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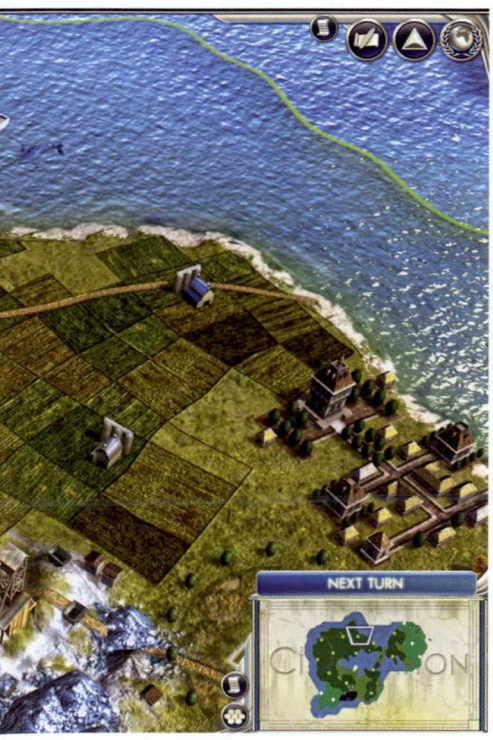

Videogames: for a better brain

At GamesLab we are working on several projects comparing cognitive training with videogames in terms of carefully selected dependent variables and mediators on both the behavioral and psychophysiological levels. This helps us gain a better understanding of psychological and psychophysiological processes underlying improved cognitive function as a result of different approaches.

By manipulating motivation levels and precise measurements of theoretically reliable dependent variables and moderators of effective training, we hope to create a comprehensive database which can be used to optimize training programs in the future. Our project will also improve our understanding of the mechanisms underpinning neuroplasticity, helping us to obtain the best results from training regimes.

We recently published a paper on "Issues and advances in research methods on videogames and cognitive abilities" (available as open access on http://journal.frontiersin.org/article/10.3389/fpsyg.2015.01451/abstract). The article compares objective and declarative data on the time spent playing videogames. The information was collected from several samples in order to illustrate variation in gaming time. We also present arguments in favor of selecting videogames by genre when recruiting participants for cross-sectional studies. This classification reflects the mechanics of games being played and provides an insight into the intellectual functions that are the most engaged. We also present the Hidden Questionnaire: Experiences with Videogames as an example of how game classification can be used during recruitment to participate in research.