Digital health: a game changer

In March 1989, Sir Tim Berners-Lee drafted a proposal that he hoped would enable scientists to easily share data with one another. Fast forward 30 years and his brainchild—the world wide web—is responsible for connecting the planet in an unprecedented way by enabling people to share information and communicate via the internet. His simple but powerful vision has made a substantial contribution to the digital revolution by providing a construct that has shaped modern life in almost every way imaginable. Digital health is one such offshoot that harnesses digital technologies and services to address health problems. Some of the advances that underpin digital health include innovative computational software and analytical techniques, smart devices, wearable technologies, and apps that are integrated through diverse communication channels. This discipline is transforming the way health care is understood, taught, delivered, and advanced—sometimes in unpredictable ways.

One area of advancement is the use of virtual reality in medicine. Virtual reality is defined as an interactive computer-generated experience that takes place within a simulated environment. This approach has been successful for the treatment of various psychological disorders as demonstrated by clinical psychologist Daniel Freeman and colleagues at the University of Oxford (Oxford, UK). Freeman, who is also co-founder of the University spin-out company, Oxford VR, develops clinically-validated, cost-effective virtual reality treatments. In August 2018, Freeman and his team published results of a randomised controlled trial in *The Lancet Psychiatry*. The team used virtual reality to deliver psychological therapy via a coach to individuals who were placed in virtual situations that caused them distress (in this case, heights). Virtual reality coaching resulted in a large and persistent clinical benefit, demonstrating the way health care is understood, taught, delivered, and advanced—sometimes in unpredictable ways.

Virtual reality is also being used to simulate surgical environments, enabling surgeons to practice in a safe and controllable space. Incorporating motion controllers with haptic feedback further enhances the surgical experience by providing tactile information. According to FundamentalVR, a UK and USA based company that is pioneering near-real operating platforms, their technology is more cost-effective than traditional training systems. The technology was named as one of the top 50 best inventions of 2018 by *Time Magazine* and has been implemented in leading hospitals across the USA and Europe. On April 16, 2019, the FundamentalVR total hip replacement simulation received accreditation from the Royal College of Surgeons (London, UK), endorsing the educational value of such technology. This shift towards the use of such systems might mark the future of surgical training programmes and further demonstrates that virtual reality is providing novel solutions to health care challenges.

Many virtual reality approaches adopted by the medical field have been derived from gaming virtual reality technology. However, computer games themselves have also been used to treat mental disorders. A study published in December 2018, in the *Journal of Consulting and Clinical Psychology*, used Tetris to treat post-traumatic stress disorder. Led by Henrik Kessler at Ruhr-Universität Bochum (Bochum, Germany), 20 patients with post-traumatic stress disorder were asked to write a description of an intrusive memory on a piece of paper, then play Tetris on a tablet for 25 min. The frequency of flashbacks decreased following the intervention, with 16 of 20 individuals reporting a reduction of more than 50% in intrusions of targeted images. Playing Tetris is hypothesized to stimulate the same visuospatial brain regions that process traumatic memories. When remembering the content of a flashback, the associated memory trace is temporarily unstable, and if interference occurs at this time, memory reconsolidation of the traumatic event might be weakened. Using a simple behavioural intervention, such as playing a computer game to alleviate unwanted emotional memories, warrants further investigation to understand the underlying mechanisms involved.

Gamer technology and computer games have been appropriated by the medical field, and gamers themselves are also being used to solve biomedical problems. A study led by Emma Lundberg at the Royal Institute of Technology (Stockholm, Sweden) analysed 322,066 gamers over a 1-year period to help annotate protein localization patterns via an online multiplayer game. This information was then combined with an artificial intelligence (AI) system to boost its predictive capabilities, resulting in the identification of ten new members of a protein family, as detailed in *Nature Biotechnology* in September 2018. Indeed, harnessing the natural intelligence of the human mind and combining it with the processing power of AI is becoming a powerful method to leverage scientific insight. The DeepMind Technologies team at Google UK—known for beating some of the best Go champions in the world—have recently used their AI capabilities to understand protein folding. In 2018, a tool named AlphaFold won the Critical Assessment of Structure Prediction competition. This event challenges research groups from around the world to predict the three-dimensional structures of proteins from lists of their amino acids. By using trained neural networks on thousands of known proteins, AlphaFold was able to predict the most accurate structure for 25 of 43 proteins, which is a remarkable feat. Furthermore, because AlphaFold uses a neural network approach it can learn by reinforcing connections that seem useful. The more data there are, the better AlphaFold performs.

Deep learning and AI strategies are increasingly being applied to solve real-world problems. Extensive datasets can be computationally analysed to reveal patterns or trends that are then used to, for example, predict scheduled hospital attendance, diagnose diabetic retinopathy
from retinal images or, as reported in this issue of *EBioMedicine* in a
study led by Thomas Sauter (University of Luxembourg, Luxembourg),
to identify repurposed drugs for malignancies using network-based
drug target prediction. Clearly, AI offers tremendous potential, but are
there caveats? The simple answer is yes. One fundamental requirement
is to ensure machine learning data is of sufficient quantity and quality to
enable a successful result. This requirement is not trivial and uninten-
tended biases can be introduced by using suboptimal input datasets
that fail to capture the variability of a population, leading to inaccurate
inference. This was highlighted by the Watson supercomputer (IBM,
New York, NY, USA), which gave unsafe recommendations for treating
patients with cancer. It turned out the software had been trained
using a small amount of hypothetical, rather than real-world data,
highlighting the need for relevant data and rigorous independent vali-
dation. Using health-care data also requires responsible curation, and
data breaches can have profound consequences. There is also a
suspicion that AI might become too influential or that humans might
become over-reliant on such systems.

Rather than a power struggle between AI and doctors, a collabora-
tive approach will likely yield the most effective digital health solutions.
Our sister journal, *The Lancet Digital Health*, has just launched and their
inaugural May issue is now online. At *EBioMedicine*, we have recently
added a new ‘Digital Health’ subject collection on our homepage and
we are currently recruiting thought leaders to our Advisory Board to
help direct our digital health strategy. Health care has much to gain
from this dynamic discipline and we are invested in capturing the
most innovative translational digital health studies. #staytuned.

*EBioMedicine.*

11 February 2019

Available online xxxx