What if AI could advance the science surrounding dementia?

Dementia is a growing public health concern, with no reliable prognosis or effective treatment methods. In the age of big data and artificial intelligence (AI) technologies, the goal of more precise, early diagnosis and prediction of the progression of dementia may not be very far away. However, solving a huge biomedical problem via AI could have a profound impact on human privacy, rights and dignity.

© Lightspring / Shutterstock.com.

Dementia is an increasingly common condition in various brain diseases described by symptoms such as a diminished ability to think, reason and remember. Dementia not only impacts the patient's daily life but also poses a huge burden on families, caregivers and on national economies. Currently, about 50 million people worldwide, including 10 million in European Union (EU) Member States, are affected, and the numbers are expected to triple by 2050. Strikingly, 5 % of these cases correspond to early-onset dementia, where the disease develops before the age of 60. Current costs of dementia in the EU are estimated at €200 billion. Contrary to cancer, heart disease and HIV, there is still no reliable method for early diagnosis, or treatment to prevent or reverse dementia.

Recent health innovations and dementia research are gaining momentum using AI algorithms. Referring to systems that respond autonomously to their environment, AI and machine learning (a subset of AI denoting the ability of computers to 'learn' without explicit programming) could identify 'biomarkers', common patterns, measurable biological molecules or functions, which are indicative of pre-onset dementia. Early diagnosis may set the first stage in combating dementia, but AI could present additional possibilities.

Potential impacts and developments

AI technologies have been employed to assist dementia patients in their daily lives and to monitor and integrate information to detect unexpected behavioural changes. Smart systems remind patients to eat or take their medication. Moreover, machine-learning applications collect and analyse speech or walking patterns over time to survey disease progression.

AI as a diagnostic tool

Up to now, dementia drug development has focused on treatments targeting later stages, with no success. Remarkably, research shows that biomarkers as well as genetic testing can be indicative up to 20 years prior to onset of the disease. Several EU-funded initiatives such as European Prevention of Alzheimer's Disease and the PREVENT research programme aim at generating extended datasets to understand the origin and development of dementia. Academic and private-sector interest in early detection has facilitated promising progress. AI is used to mine complex 'big data' obtained from brain scans, blood and spinal fluid samples, to identify factors as well as metabolic alterations that are predictive of dementia. Non-invasive methods such as blood-based testing could provide a particularly affordable route to tracking dementia progression. Early diagnosis is crucial to manage dementia and improve patients' quality of life.

AI as a treatment tool

As AI technologies progress, interdisciplinary efforts by neuroscientists and AI experts create maps of nerve cell connections in the brain. What if, in the future, we could have access to human brains (neural networks) like Google maps? What if one day we could create a backup and restore our minds when necessary, such as in the case of getting dementia? Substantial amounts are being invested in several large-scale research projects such as the EU's Human Brain Project (HBP), the United States' Brain Research Initiative and Japan's Brain Project, which are working towards an understanding of how, on the structural and functional level,

Author: Lieve Van Woensel with Sara Suna Lipp, Scientific Foresight Unit (STOA)

PE 641.546 – June 2020

millions of neurons come together to make the brain work, generate and store information. Furthermore, there are several companies researching links between the human brain and computers, 'brain-machine interfaces', to preserve and enhance brain function, with additional potential to treat brain disorders causing dementia. Neuralink, founded by Elon Musk, intends 'to implant computer chips into human brains and to develop brain-machine interfaces connecting the mind to external processing power'. Similarly, Kernel, founded by Bryan Johnson, states its objective as 'to read and write the underlying functions of the brain'. Although mapping the complete human brain is far from a reality, rapidly evolving science and technology may bring developments that until recently sounded like science fiction.

Despite its promise, using AI to fight dementia raises ethical and societal concerns. All these developments depend on the collection of very sensitive data – comparable to genetic data – operating in close proximity to the human body. Privacy, data governance and informed consent will therefore be important issues to address. Results obtained by AI algorithms for early diagnosis may be difficult to comprehend and explain, even by experienced physicians – raising issues of trust. Do people trust more in decisions made by machines or by humans? And what happens in the case of erroneous diagnosis? Who would be accountable for incorrect treatments and how would damage be compensated? In addition, inequity in accessibility to the technology may lead to a growing social gap.

More complex scenarios emerge when considering whether AI-powered brain-interface technologies could be utilised as a dementia treatment to restore brain information. Could a person's personality be changed? What happens to autonomy and free will? How easy would it be to manipulate or change people's thoughts? How would human relationships be affected, knowing that a person is partially governed by a programmed machine? Non-therapeutic human enhancement, such as creating 'super-smart' people, could lead to very controversial dual-use of this technology. Lastly, technological foreign invasion of the brain could cause major cybersecurity issues, such as hackers being able to target brains instead of computers to extract information (i.e. financial, political), or to manipulate people's ideas. The possibilities for misuse of AI technologies therefore pose fundamental challenges to basic human rights, dignity and even personhood.

Anticipatory policy-making

AI research and development in dementia diagnosis and treatment require close attention to several legal and ethical issues: privacy, autonomy, data protection, cybersecurity, surveillance, dual-use, transparency, accountability and non-discrimination. Due to the strategic importance of AI and its future use, the European Commission published a White Paper and European strategy for data in February 2020, setting out policy options and measures for a European approach to AI and big data. The OECD Recommendation on Responsible Innovation in Neurotechnology, released in December 2019, is the first international standard aiming to guide governments and innovators to plan for and address challenges in the field of brain research. The OECD Recommendation's principles can assist the EU to build on existing rules.

Medical/brain data are highly sensitive. Therefore, policy-makers must ensure that data storage and transmission methods are vigorous and secure. Potential use of the technology 'to read and write' the brain may threaten privacy and autonomy, and cybersecurity requires rigorous implementation of safety and security standards. Today's legal framework may be unable to react to these serious concerns. Societal deliberation, increased oversight and advisory-body capacity are essential at the early research and development stage.

AI-powered brain interfaces necessitate a code of conduct and surveillance mechanisms. Due to the potential dual-use/misuse, legal guidance criteria to define legitimate and ethically permissible use of brain data are required, and risk assessment within a common EU framework is crucial. Currently, a Commission draft proposal for a risk-based approach is open for consultation, and a legislative proposal is expected in late 2020. Furthermore, transparency and informed consent procedures require re-evaluation to provide legal protection for long-term safety and against risks. Legal responsibility needs attention as erroneous diagnosis/actions impact issues from safety to privacy. Finally, future laws should ensure non-discrimination and fairness through equal distribution and accessibility to these technologies to avert social inequalities.

The author is grateful to David Winickoff, Senior Policy Analyst, Division of Science and Technology Policy, OECD, for the inspiring feedback and input on neurotechnology.