05 A Big Data approach for predicting brain health

Robert Whelan

In recent years, there has been great progress in understanding how the brain works, but there is a still a huge gap between laboratory results and their real-world application. My research tries to bridge this gap. The long-term goal is to use brain data to identify psychological disorders or neurodegenerative diseases, in order to predict the future course of the illness, or to ascertain if a particular medication will be effective.

One reason why it is difficult to predict real-world outcomes is because the brain is incredibly complex, with billions of cells. In my laboratory in the Trinity College Institute of Neuroscience, we often use 'Big Data' methods to help overcome these difficulties. Tools developed to help you find the right webpage or to recommend a good movie have proven very useful when applied to neuroscience problems. Big Data approaches require...big data. Therefore, my work is characterized by collaboration, both with Trinity researchers (e.g. The Irish Longitudinal Study on Ageing, TILDA) and further afield in Europe, Asia, Australia and the US.

How old is your brain? – Having a brain that is 'younger' relative to chronological age is associated with many health benefits, but the precise relationship with psychological processes was previously unknown. Using about 1,400 publicly available 3D brain pictures captured using magnetic resonance imaging (MRI), we first trained an algorithm to predict a person's age using only their brain image. Next, we took hundreds of other brain images – collected in Trinity, and from collaborators in the US and Turkey – and showed that having a younger brain was specifically associated with faster processing speed and cognitive flexibility, both crucially important in the context of ageing.

Brain waves – We have applied the same Big Data approaches to measurement of the brain's electrical activity – a simpler and less costly approach than MRI. This allowed us to identify differences in brain connectivity of adults with a diagnosis of attention deficit hyperactivity disorder (ADHD). In a separate study, we classified young adults with a propensity for risky alcohol use. Identifying such brain signatures could eventually allow us to monitor ADHD symptoms or identify those at risk of alcohol misuse.

Into the wild – My medium-long term goal is to collect data 'in the wild'. In recent work, in conjunction with an industry partner, older adult participants self-administered their own EEG on a near-daily basis. This produced brain data that were very reliable. Multiple days of recording markedly improved the quality of the signal, which could be important for monitoring brain health over time. A more mobile approach could also be useful for improving access to healthcare in remote or underserved regions.

A key goal of my ongoing research is to study how the brain changes over time and how this relates to clinically relevant outcomes. For example, we are measuring how the brain's 'wiring' (see Figure 1) changes over time in adolescents diagnosed with ADHD and how this relates to their symptoms. Other work examines the antecedents and outcomes of substance use in adolescents and young adults, and functional brain connectivity associated with cognitive performance in older adults. I am currently editing a book on the practical application of Big Data methods to neuroimaging, with the aim of making these methods more accessible.

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Robert Whelan received an Applied Psychology degree from UCC and a PhD from NUI Maynooth. He joined UCD as a lecturer in 2013 and Trinity in 2016 as Associate Professor of Psychology at the Global Brain Health Institute and the School of Psychology. Robert was elected a Fellow of Trinity College Dublin in 2020. Current and previous funding sources include the Health Research Board, Science Foundation Ireland, and Brain and Behavior Research Foundation, among others. He has published 180 peer-reviewed articles, primarily in the areas of cognitive neuroscience and neuroimaging methods.
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FIG 1 – The image shows the key structures and connections of a single participant's limbic lobe, a region important for memory and emotional responses. The image was generated using constrained spherical deconvolution tractography from high angular resonance diffusion-weighted magnetic resonance imaging.

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