BJPsych Advances (2023), vol. 29, 428–429 doi: 10.1192/bja.2023.26

REFRESHMENT

Digital phenotyping in psychiatry*

Simon Williamson

Simon Williamson, MBBS, MPhil, is an Academic Clinical Fellow in General Psychiatry at the University of Warwick, Coventry, and a Core Psychiatry Trainee with Coventry and Warwickshire Partnership NHS Trust, Coventry, UK.
Correspondence Dr Simon Williamson. Email: simon.williamson@warwick.ac.uk

First received 10 Sep 2021
Final revision 12 Apr 2023
Accepted 17 Apr 2023

*This article is adapted from an essay submitted for the Duncan Macmillan Essay Competition, run by the Institute of Mental Health, Nottingham, in 2022 (https://institutemh.org.uk/about/awards/1665-2022-duncan-macmillan-essay-prize-competition-winners-announced).

SUMMARY

Advances in data science and machine learning have allowed for the analysis of increasingly complex and large data-sets. Digital devices are a source of such data, given their ability to collect information on users continuously and irrespective of location. Digital phenotyping aims to use these data to build a comprehensive picture of an individual's behaviour. Psychiatry is well-positioned to make use of this, since digital behaviour may be reflective of mental state. This article provides an overview of the field of digital phenotyping as it stands currently, on the verge of large-scale studies which may pave the way for clinical implementation in psychiatry.

KEYWORDS

Personalised psychiatry; digital phenotyping; digital psychiatry; mobile mental health; digital intervention.

Digital devices are now an integral part of our modern lives. Interactions with smartphones and wearables comprise a substantial portion of our waking hours. Consequently, these devices can generate large amounts of data reflecting our behaviour. For psychiatry, these data are a rich, yet untapped, resource.

Digital phenotyping has been described as the 'moment-by-moment quantification of the individual-level human phenotype *in situ* using data from personal digital devices' (Onnela 2016). In other words, it is the use of digital data to generate a behavioural phenotype that is both continuous and ecologically valid.

Observation of behaviour is fundamental to psychiatry, insofar as behaviour manifests mental illness. Mental health fluctuates with time and is largely environmentally dependent, yet patients are often observed cross-sectionally in clinical settings outside of their normal environment. Digital phenotyping promises to remedy this and, moreover, offers the potential for a more objective, proactive and personalised psychiatry.

Extending the MSE

The mental state examination (MSE) is a primary means of determining mental state through observation. Digital phenotyping provides new means to observe behaviour, in a sense extending the psychiatrist's sensorium.

Data from digital devices are differentiated into active and passive forms. Active data require user engagement to obtain, for instance the completion of a questionnaire (i.e. ecological momentary assessment (Stone 1994)). Passive data, conversely, are collected without explicit user notification. Forms of passive data include the number of text messages sent, accelerometery and geolocation. With the addition of a wearable device, actigraphy, heart rate and skin conductance also become available.

There is growing evidence that these data are genuinely informative. Several studies demonstrate that variability in depressive symptoms within individuals is well captured. A recent systematic review found that features sensitive to depression are also sensitive to mania, reflecting the bipolarity of mood (Maatoug 2022).

Moreover, work continues to generate new and informative features. Speech analysis shows great promise in quantifying the dysconnectivity inherent in thought disorder, while pulse wave analysis offers a more nuanced view of the physiology captured by heart rate monitors. In addition to smartphones and wearables, the potential to acquire digital biomarkers in gaming contexts has also been recognised (Mandryk 2019). The emerging picture is one of several digital biomarkers of mental health which, in combination, could be a powerful adjunct to the MSE in inferring mental state.

From phone to phenotype

Although the development of new features is exciting, combining them to generate clinically useful phenotypes is not trivial. Real-world data are noisy, patchy and sizeable. Unlike in neuroimaging or genomics, there is no standardised method to analyse data from digital devices. So how can this be achieved?

The first step is to collect and organise data on the device itself. Several applications exist for this purpose and automatically upload collected data to secure servers. Once uploaded, the data require preprocessing (i.e. cleaning) before features can be selected for further analysis.

The goal is then to model digital behaviour such that it represents, with reasonable accuracy, the individual's mental state and functioning. Barnett et al achieved this by statistically modelling trends in digital features over time. When new data were significantly different from what would be expected

from the trend, anomalies were flagged. In people with schizophrenia, the rate of anomalies 2 weeks prior to relapse was 71% higher than at other times (Barnett 2018).

Even more promising are machine learning models, which are highly suited to large, multimodal data-sets. Currently there is marked heterogeneity between studies and impressive performance should be treated with caution. As the field matures, however, we are likely to witness increasingly powerful digital phenotypes.

Closing the loop

Clinical implementation is essential if digital phenotyping is to have a meaningful impact on psychiatry. When a model detects changes in mental state, the opportunity to intervene arises. This is referred to as closing the loop and could encompass relapse prevention, recognition of treatment non-response or timely delivery of a digital therapy (i.e. ecological momentary intervention (Heron 2010)).

For inclusion in clinical practice, a coherent overarching system linking phenotypes to interventions will be necessary. Several groups have begun this work, starting with the development of 'clinician dashboards' – interfaces for viewing digital data in much the same way as blood test results.

Importantly, clinical implementation can only proceed if digital phenotyping is acceptable to patients. The ethical issues surrounding use of personal data are apparent (Birk 2021) and careful collaboration with patients will be necessary to ensure that individuals are empowered by their data should they choose to share it.

Conclusions

Digital phenotyping is a fast-growing field with real implications for psychiatric practice. Initial evidence has effectively proved the concept, with larger-scale studies currently underway. Experts across fields, as well as patients, will be needed to actualise digital phenotyping in its entirety. Centralised repositories for sharing data will likely be invaluable for overcoming the current issues of heterogeneity, and incorporation of digital phenotyping into existing research frameworks will help to better guide studies and contextualise findings (Torous 2017). As for clinicians, blind enthusiasm should be avoided as with any new technology. We can, however, remain hopeful that a truly 21st-century psychiatry is close at hand.

Funding

This article received no specific grant from any funding agency, commercial or not-for-profit sectors.

Declaration of interest

None.

References

Barnett I, Torous J, Staples P, et al (2018) Relapse prediction in schizophrenia through digital phenotyping: a pilot study. *Neuropsychopharmacology*, **43**: 1660–6.

Birk R, Lavis A, Lucivero F, et al (2021) For what it's worth: unearthing the values embedded in digital phenotyping for mental health. *Big Data & Society*, **8**: 20539517211047320.

Heron KE, Smyth JM (2010) Ecological momentary interventions: incorporating mobile technology into psychosocial and health behaviour treatments. *British Journal of Health Psychology*, **15**: 1–39.

Maatoug R, Oudin A, Adrien V, et al (2022) Digital phenotype of mood disorders: a conceptual and critical review. *Frontiers in Psychiatry*, **13**: 895860.

Mandryk RL, Birk MV (2019) The potential of game-based digital biomarkers for modeling mental health. *JMIR Mental Health*, **6**(4): e1348.

Onnela J-P, Rauch SL (2016) Harnessing smartphone-based digital phenotyping to enhance behavioral and mental health. *Neuropsychopharmacology*, **41**: 1691–6.

Stone AA, Shiffman S (1994) Ecological momentary assessment (EMA) in behavorial medicine. *Annals of Behavioral Medicine*, **16**: 199–202.

Torous J, Onnela JP, Keshavan M (2017) New dimensions and new tools to realize the potential of RDoC: digital phenotyping via smartphones and connected devices. *Translational Psychiatry*, **7**(3): e1053.