

Digital biomarkers for the prediction of mental health in aviation personnel

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Researchers have proposed to use information from digital sources such as smartphones and wearable technology to objectify patient mental health characteristics. Using big data analysis methods, patterns can be detected. This is called digital phenotyping. In this communication, we will discuss the use of digital phenotyping for professionals in aviation. We choose this very specific area of medicine because there have been several aviation crashes in the last years that were due to a mental problem of a pilot.¹ The mental health of flight crews remains one of the biggest challenges for improving aviation safety. Digital biomarkers may be highly promising here, while at the same time easily misused, with enormous consequences. Of course, most of our findings may also be applicable outside this area.

Digital phenotyping can include smartphone sensors, keyboard interaction and voice and speech features, but it can also go as far as social media posts, internet searches and Bluetooth recognition of other mobile devices.² The value of digital phenotyping is that it offers a multidimensional and measurable method to objectively gather patient data. Whereas a clinical interview by a psychiatrist only provides static information in an artificial setting, smartphone data are collected throughout the day in the patient's daily setting.³ Furthermore, clinical interviews are dependent on the therapist's interpretations, in contrast to smartphone data which are unbiased and quick to assemble.⁴

The most important challenges of digital phenotyping and ways to overcome these are summarised in [table 1](#). An important risk is that the privacy of the patient may be violated or that the amount of assembled information might be perceived as being intrusive. As a possible solution, it has been proposed to collect only 'content-free' data, such as human-computer interaction.³ This would mean, for example, that the manner in which someone types is analysed without gathering

the content of what is being typed, with the purpose that no personal information can be extracted from it. Still, combinations of data and context information can provide valuable personal knowledge. Therefore, the data use should be strictly regulated.

In our opinion, digital phenotyping is most promising for monitoring those with already identified mental conditions, on a voluntary basis. It should not be used for random screening for mental disorders. This would be a too large infringement of privacy. Especially when people are under pressure by their employer, they might be persuaded to agree to giving access to their information, while not actually consenting to the privacy risks. Also, in an unselected population, the risk of false-positive results increases, which means that someone is wrongly identified as being at risk for or having a mental disorder. On the contrary, digital phenotyping might be useful to monitor pilots who are being treated or have recovered from mental health problems and who consciously agree to the use of digital phenotyping. Then, it might help clinicians to better predict recovery or early relapse, and could perhaps even shorten the period a pilot is being grounded for mental health problems. It should not be used to replace clinical examinations, but only to provide additional information to clinicians, to improve the quality of clinical examinations. When combined with normal clinical care, the risk of false-positive and false-negative results diminishes, as well as the risk of 'gaming', meaning that patients will do things only to let the algorithm show better results.

A systematic review about the use of digital phenotyping for patients with affective disorders shows that there were 27 feasibility studies investigating digital biomarkers. The studies reported the association between mood status and phone usage (9 studies), physical activity (8), location (8), voice features (8), light exposure (3) and heart-rate



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**Table 1** Using digital phenotyping for mental health in aviation professionals

Challenges regarding digital phenotyping	Possible solutions
Reliability: how well do digital biomarkers associate with mental health?	<ul style="list-style-type: none"> ▶ More RCTs comparing digital phenotyping with clinician's prediction ▶ Comparison of different parameters ▶ More research into developing algorithms ▶ Investigating the use of machine learning ▶ Research in healthy individuals
Clinical utility: does it help to improve symptoms and clinical evaluation?	<ul style="list-style-type: none"> ▶ Testing benefits of quick detection of onset/relapse ▶ Research into role of monitoring in treatment or during follow-up ▶ Defining clinical outcomes based on symptoms in future studies
Privacy: how much personal information will be gathered?	<ul style="list-style-type: none"> ▶ Data are regarded as medical data to which medical confidentiality laws are applicable ▶ Protection of data by dedicated regulation ▶ Restricted amount of and 'content-free' data modalities ▶ Retractable informed consent
Regulation: who is accountable for proper use and protection of data?	<ul style="list-style-type: none"> ▶ Only approved apps: guidance for clinicians ▶ Only use by healthcare professionals ▶ Healthcare professional is responsible for choosing reliable commercial apps
Application: what should it be used for?	<ul style="list-style-type: none"> ▶ Monitoring, but not screening ▶ Not mandatory

RCT, randomised controlled trial.

variability (2). Twenty studies (also) included subjective self-assessments. The quality of the studies was limited, as many did not have a control group, used small sample sizes and had a short follow-up period. The data analysis that was applied differed regarding the number of analysed parameters and what algorithm was used and consequently, efficacy results were inconsistent.⁵ Only one randomised controlled trial was reported in the systematic review. This study showed that in bipolar patients an intervention consisting of daily self-assessments did not yield significant change in either depressive or manic symptoms, compared with the control group.⁶

Therefore, digital phenotyping is an interesting innovation, which developments should be watched closely, but critically, as there should be considerably more research into the association between digital measurements and mental health as well as the clinical utility. It has potential to be beneficial in mental disorders in aerospace medicine, but there are important technical and ethical challenges, regarding effectiveness, privacy and regulation.

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