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The Informatics Revolution and CNS disorders

17th LINF Faculty meeting,
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Lundbeck Institute

Art Contribution

About The Cunningham Dax Collection

The Cunningham Dax Collection consists of over 15,000 artworks created by people with an experience of mental illness and/or psychological trauma. The art includes works on paper, paintings, photographs, poems, textiles, sculpture, journals and digital media. The unique Cunningham Dax Collection is now one of the largest of its kind, with only two other similar collections of comparable size and stature: the Musée Art Brut in Lausanne, Switzerland, and the Prinzhorn Collection in Heidelberg, Germany.

The Dax Centre is a not-for-profit organisation that relies on the generosity of the community to carry out its mission of promoting mental health through art. We aim to change community attitudes to mental illness by increasing empathy and understanding of mental illness, psychological trauma and the mind through art, thereby reducing stigma against mentally ill people. The Dax Centre holds an important history and clinical focus, but it is today visited by many people such as students from a diverse range of learning purposes, artists and those interested in art, community and special interest groups; all who seek to demystify mental illness and address the associated stigma that has historically underpinned individual and community perceptions of mentally ill and traumatised persons.

Editorial

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How Technological Advancements Will Revolutionise Healthcare

There are few things all doctors will agree on, but I suspect that all would concur with the claims made in the following three articles: The rise of the age of information and social media will have a huge impact on healthcare. On the downside, there is the 24/7 access to problematic behaviours, such as online gambling and pornography, that will lead to more compulsive behaviours and dependence problems.

On the upside, we already have access to online programmes to help treat anxiety and depression through cognitive and behavioural approaches. But there is much more to come. As the three articles explain, the data gathered from use of the internet and social media could alter both the collection of data on mental illnesses as well as potentially drive improvements in education and treatment of these disorders.

At the most straightforward level, easy access to information on when and how someone's mood or thinking processes are changing could facilitate early access to treatment services. At a more advanced level, searching for terms such as "voices" or "feeling paranoid", which can be detected by search algorithms, will make it possible – with appropriate controls in place – to more quickly identify people with incipient depression or schizophrenia. They could also be monitored more effectively through the internet and through activities such as their texting rates and content. Wearable devices such as heart rate and sleep monitors linked to mobile phones could be used to measure the adverse effects of medication and direct activity programmes to minimise these.

The power of repeated sampling via the ecological momentary assessment (EMA)

Contents

Joan Rodriquez,
Birth into Chaos, 1987.
'It can always be stirred up
again by life's circumstances.'

For more information on the Cunningham Dax
Collection and The Dax Centre, visit:
www.daxcentre.org

approach could also be used as a more fine-grained analysis to evaluate the effects of new treatments. Sampling moods four or more times a day is possible using PDA-based questions, which is much more than one could ever do with the traditional out-patient clinical trial assessments. In theory, feedback from these reports could also be used to help people work to improve behaviours that could lift mood, though there is always the possibility that negative outcomes could emerge. For example, a depressed person might become more despondent if they are repeatedly told on their phone that their mood seems to be dropping. Of course, similar issues will be present in relation to schizophrenia where the idea of being monitored might accentuate paranoia.

Beyond this, we get into the more science fiction area of using electronic communica-tions to develop new treatment approaches. Cross-linking social media activity could be used to explore the effects of season, temperature, viral infections and more on population mood and behaviour. These could help inform public health interventions.

In the end, the vast data that can be collected using electronic technology will become merged with other "large data" sets, such as genetic variants and health and education records. Such interactions could potentially lead to a whole new approach to diagnostic and epidemiological medicine. The three following articles give a clear and concise perspective on current possibilities and future potential of these rapidly evolving technologies.

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Digital Disruption Approaches Healthcare

Social media and mobility are transforming the treatment of mental health. The relatively new fields of predictive modelling and mobile healthcare technology are changing the ways previously unobtainable data streams can be collected and analysed.

Big Data and Computer Learning

Since 1900, computing power has been increasing at an unprecedented rate with some experts suggesting that by 2045, the computing power of all humans on the planet will be available on one computer chip (Grossman, 2011). With the availability of all of this computing power, there has been a substantial increase in "datafication" of the world, assigning values (i.e. pace, heart rate, response time etc.) to a myriad of behaviours, activities and events. As the amount of data expands along with computing power, it is possible to process data in stronger and more robust ways, offering complex analyses that were impossible to achieve in previous eras. These improvements expand into several areas, including big data/computer learning, mobile technology and social media, ideally cumulating in a significant improvement due to the digital transformation of healthcare.

One process that has been particularly instrumental in this process is the concept of machine learning. This type of programming allows computers to adapt categorisation algorithms according to successes and failures, as defined by a user's input (Bongard & Lipson, 2007; Bongard et al., 2006). As the computer gains more cases from which to base its categorisation process, it becomes increasingly accurate, based on the accuracy of the user in defining success and failure. One of the best-known examples of this would be the "Watson", the learning computer that competed on the television game show "Jeopardy". Through an aggregate learning process, computer scientists were able to create a "learning" computer that eventually yielded a computer that was capable of competing on, and winning, Jeopardy. Watson and other systems, such as the Eureqa computer, have now started to see increased use in the medical field as well. Following its success on Jeopardy, Watson was adapted to help oncologists improve patient care, aggregating the most up-to-date information from medical journals and other resources to provide recommendations based on previous evidence (International Business Machines Corporation, 2015). Similarly, the Eureqa system has been useful in a number of biological assessments, specifically in building predictive models based on raw data from previous behaviours within a chaotic system, an important process in many basic research studies. Given the successful implementation of both of these
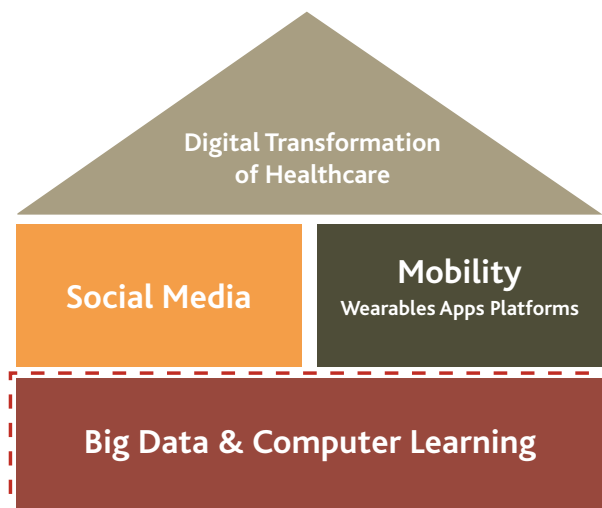
Leslie Holding, *No title*, c. 2002, 'I do my art to seek enjoyment on how others find my works pleasing. To satisfy the beholders of my works is the motivation I have while I do art. Most of the time when creating works, I ask others of what they think (of my works). After some time, I also like to ask, how does my artwork make them feel? I hope good.'
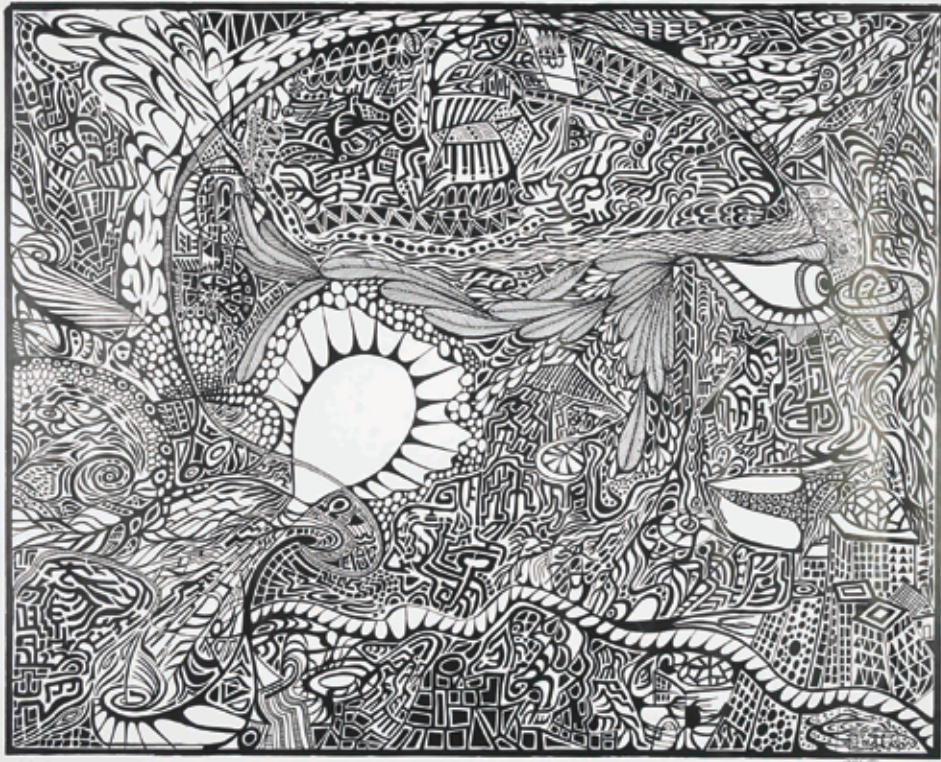
James Dickson
*Light Inventions and
Rings of Power*, 1981
Screenprint, edition 49/100

systems, it has become clear that computational modelling and computer learning may be a crucial tool for physicians and medicine progresses and will become more complicated.

Social Media: A New Wealth of Data

While the amount and availability of data in the world has been increasing rapidly in general, social media has become one of the most salient sources of data available, including information from users creating new data, sharing information and networking. Considering Twitter alone, 100,000 tweets were produced every 60 seconds during 2009, a number which has continued to grow rapidly over the past five years (Go-globe.com, 2015). This increasing amount of sharing and interconnectivity is a significant development not just for the entertainment and news industries, but also the medical field. A survey of tweeters and social media uploads conducted in 2012 found that 28% of patients report supporting a health-related cause, 27% report commenting on health experiences or updates, and 16% report posting reviews of medications, treatments, doctors or insurers

(Manhattan Research, 2012). These numbers indicate that a rapidly increasing number of patients are sharing more than just cute cat videos and updates on vacations. A notable portion of the population is actively using social media to both influence medical decisions and share experiences with other users. In particular through online communities devoted to specific problems such as depression, addiction and diabetes. These communities and message boards, although often unmoderated, are a common resource for patients looking for additional information about specific disorders and health in general.

With this abundance of information available through Facebook, Twitter and other social media outlets, research groups have started to use this information in an effort to aid in predicting the course and prevalence of diseases. Such efforts have already demonstrated utility in assessing one of the most common and impactful public health problems in the world: influenza trends within the United States. Lazer and colleagues used a wide range of search terms to fit a specific set of 1,152 data points related to influenza prevalence (Google Flu Trends, 2013). While this methodology encountered notable problems

in overestimating rates of the flu, the research offers an initial indicator that such methods of prediction modelling are possible (Lazer et al., 2014).

Within the field of mental health, researchers have been pursuing a similar goal to the predictive influenza modelling in the US, using information garnered from social media to create predictive models of psychiatric disorders. In one study conducted by De Choudhury and colleagues, researchers assessed a population of 476 Twitter users to aggregate information on their social media use and possible history of depression (De Choudhury et al., 2013). Using this information, they were able to build a predictive model for depression that could be applied to other populations of Twitter users. When doing so, the model was able to predict the presence of depression at a 70% accuracy level, based solely on their activity on Twitter, such as "tweeting" new posts and responding to posts from other users. From this information, the study team is working to use machine learning to refine the accuracy of the predictive model and improve its predictive utility. Given this initial success with depression, it is possible that a similar model can be applied to a wider range of

disorders, potentially allowing earlier detection and intervention for severe psychiatric illnesses.

Mobile Applications: A "Real-Time" Data Stream

The internet is not the only emerging way to collect, analyse and assess data. The increasing popularity of mobile devices to track various aspects of health, activity and other information offers a naturalistic view of behaviour that has previously been difficult, if not impossible to assess. These devices come in many styles and shapes, including phone apps and wearable media, including wrist watch trackers, clip-on devices, even glasses. Many companies have already started designing technology to assess important health information for persistent disorders, such as diabetes. Some apps, such as GINGER.io, assess a myriad of data both actively through daily mood scores and self-report data as well as passively using calling patterns, text messaging activity and location assessments. From this information, the app is able to aggregate the information and analyse it for a number of uses, such as statistical analysis, classification and important notifications for the patient, clinicians or researchers. From this data, the app can generate alerts in response to certain criteria pre-specified by programmers, such as a spike in risk for a pre-determined event, e.g. relapsing into a psychotic episode or using a noted substance of abuse, such as alcohol.

The implementation of these devices in a research setting has already shown promising results. In a study conducted by Wang and colleagues, researchers assessed 48 students using an app tracking passive data including social interactions, physical activity, sleep and stress (Wang et al., 2014). Based on this information, the app was able to make significant predictions about individual students' grades and stress levels. What made this research particularly notable is that this was achieved without using any active data input from the participants, such as surveys or other measures. It was purely based on data. This "datafication" of daily activities was sufficient to allow researchers to create a predictive model for academic achievement and stress, two of the most salient concerns for both students and academic institutions. While previous analyses have attempted to show similar associations, these analyses were hampered by the limited naturalistic validity of survey data collected in a lab. The data obtained in this particular study, however, was able to assess students in real-time, providing a more objective and accurate depiction of the students as they interact throughout the day.

Future Goals for Healthcare Technology

Although the fields of predictive modelling and mobile healthcare technology are still relatively new fields, they have already started to offer revolutionary ways of collecting and analysing novel data streams that were previously unavailable to clinicians and researchers. As the sophistication of healthcare technology and computation progresses, it will be important to consider how this technology and "datafication" process will affect patients, with particular emphasis on optimising patient care and improving access to medical services in underserved populations. Ideally, increased use of inexpensive apps and devices to track health information will be applied to achieve an overarching goal of truly "personalising" the field of medicine. If clinicians are able to integrate advanced predictive modelling, passive data collection and social media presence, it may be possible to better tailor treatment options to the specific needs of a patient, without expending an increased amount of time. The predictive modelling already in use for social media and other devices offers a direct, inexpensive way to bring this quality of care to a wider range of patients. Similarly, by digitising data and diagnostic tools, it may be possible to improve patient access to more specialised care, particularly in areas where mental health providers may be lacking. Rather than relying on proximity to a primary care doctor to direct them to a specialist, patients may be able to rely on a mobile analytic system to optimise the care they pursue based on limited income, mobility, or other factors. In sum, advances in computation, "datafication" and social media have already started to revolutionise the way that patients, clinicians and researchers interact. Moving forward, it will be important to ensure that this technology and advancement is used to better serve patients and families, making healthcare both more effective and approachable for patients with a wide variety of backgrounds and health concerns.

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Joan Rodriquez, *The Dark Lady*, 1980, 'A calmer look at the same story.'

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The Use of Social Media as a Novel Tool to Educate, Engage and Improve Pathways to Care

With the increasing popularity of social media, it is important that mental health providers, researchers and advocates constantly improve their understanding of how the internet is used to obtain information, communicate and seek help.

Since the advent of the internet, the amount of raw data available in the world has expanded at an unprecedented rate, with 90% of data in the world (at the time) being created between 2011 and 2013 (Bradshaw, 2013). Despite this abundance of information, much of which is highly relevant to health-care, it is often difficult to translate these data into clinically meaningful information. Given these issues, the pressing concern is how to best make use of the volume of information available to the clinician in order to improve patient care and patient outcomes. This issue is particularly important in the field of mental health, which has been gaining increased visibility with the rising popularity of social media and other digital technologies (Common Sense Media, 2012; Skinner et al., 2003; PEW Research, 2013).

Educate and Engage: Promoting Help-Seeking Behaviour for Psychosis

One area in which this increased volume and access to data could be useful in a health care setting is in improving the rates of early intervention for severe mental health problems. In particular, previous research on psychosis has indicated that both increased duration of psychosis and delayed intervention for these persistent episodes are associated with numerous problems, including: greater decrease in functioning, loss of educational opportunities, impaired psychosocial and vocational development, potentially poorer response to treatment, and increased personal suffering and family burden (Perkins et al., 2005). Psychosis is a particularly burdensome problem for patients and families, as its symptoms are frequently difficult to control, and often appear bizarre to those around the individual, which can lead to stigmatisation, social rejection and further isolation (Addington et al., 2015). Given the unmet needs related to unrecognised and untreated psychosis, there is a clear need for early identification and treatment of this severe mental illness. Prior efforts in this area have included educating general practitioners, school and community officials and anti-stigma campaigns amongst other initiatives (Lloyd-Evans et al., 2011). Few of these efforts, however, have yielded a substantial impact on improving early recognition and treatment of psychosis. Limited success in more traditional education avenues such as direct contact with community members and mental health specialists or targeted information campaigns, may suggest that rather than pushing forward with these modalities, the internet and social media are more optimal tools for reaching teens and young adults and guiding them towards needed health services, particularly for the early recognition and treatment of psychosis. This shift in focus is highly supported by the increased utilisation of social media by young adults and teenagers, the target population for early interventions. It is particularly important to reach young adults, because recent research on the persistence of psychosis has suggested that the longer an initial episode of psychosis persists untreated, the worse the anticipated response to later treatments and interventions (Marshall et al., 2005; Addington et al., 2015).

A series of studies have found that the significant majority of teens use social media, and many rely on the internet to inform them about both physical and mental health (PEW Research, 2013). With this increasing online presence amongst the target population, the internet and social media may offer a more direct way to access patients than was previously possible.

In order to assess how to best use social media and the internet in order to improve early recognition of/intervention for emerging psychosis, it is important to understand what resources and information are available online, and how these resources might impact help-seeking behaviours. To answer this question, Birnbaum and colleagues (2014) assessed the current state of online and social media resources for psychotic symptoms, and the expected impact on help-seeking behaviour. In this study, the researchers entered various search terms into popular search engines and assessed the top findings to categorise them as "promoting help-seeking", "delaying help-seeking" or "undetermined impact".

The findings indicated that the majority of resources had an undetermined impact, meaning that while they did not necessarily promote help seeking, they also did not discourage help seeking. Results from Twitter and Facebook (two popular social media sites) varied widely, with select resources offering beneficial information, but with many only offering unmonitored forums with significant disinformation. In all, the study found that few of the first few hits for related search terms directly encouraged help-seeking behaviour, with the majority being unmonitored chat forums that did not offer a unified message to encourage help-seeking. The remainder of results showed a concerning level of discouraging language, including promoting stigma, normalisation of potentially psychotic experiences or information unrelated to mental health. While direct terms such as "schizophrenia" and "psychosis" yielded more helpful information, this limited avenue of access is problematic for patients who may not be familiar with these terms prior to first-contact with a mental health care provider. From these findings, it is fairly clear that the field of mental health is not using the internet and social media sites optimally to encourage help-seeking behaviour.

Pathways to Care: Using Social Media to Improve Access to Care for Psychosis

In addition to improving the information available on websites, Facebook pages and Twitter accounts, social media presence may offer important indicators of illness progression or even predictors of relapse to a psychotic episode. This type of data analysis,

NEG, *Untitled*, undated.
'Black humour is a good defence: if you don't laugh you'll cry, the choice is easy. It's the crying escapes me.
Bereft: The timeline of grief takes no account of age or readiness. It's the place that never heals, or at best only heals over and opens up, gaping wide again if the circumstances decree. Three losses at once and the rest come back to haunt. Too much for this twit's heart....
Like when my sister-in-law took me to see the work of an acquaintance who had won the RHS Medal for Botanical Art. It was love at first sight. Such beauty. I just stood there, in front of those paintings caught up, and my mouth hanging open. You know what it's like. You do.
Just listen to Allegri's 'Misere'.'

using social media, has demonstrated some utility in other psychiatric disorders, such as postpartum changes in emotion and behaviour as well as major depression. These studies were able to take the information provided by Twitter and Facebook accounts and assess select clinical variables (De Choudhury et al., 2013a; De Choudhury et al., 2013b). Based solely on the information collected from social media posts and general activity, researchers were able to delineate features related to depression and other clinical considerations, without the use of extensive questionnaires or in-person interviews.

Researchers have also employed a similar methodology to characterise the behaviour of patients diagnosed with psychosis on social media sites such as Twitter and Facebook. Birnbaum and colleagues (2015) sought to create a questionnaire that assessed individual patient's trajectory to care, the psychological factors and resources that contributed to that decision, and how clinicians can use social media to influence this process. The questionnaire, employed in a study of 55 young adults (mean age 21 years), assessed numerous factors that may have contributed

to the ultimate decision to seek help, including but not limited to Internet and social media factors. Participants had a diagnosis of either a psychotic spectrum disorder or non-psychotic mood disorder. The researchers found that 54 of the 55 participants used social media, with the majority reporting a current Facebook account, and many other reporting accounts on other sites such as Instagram and Twitter. Additionally, patients spent a significant amount of time on the websites; at least two hours a day. Changes in social media behaviour prior to seeking help were a notable factor in preceding emerging problems with psychosis and mood dysregulation, with 71% reporting a change in behaviour prior to seeking help, 22% discussing changes on social media, and 16% indicating that they had shared their psychotic experience on social media. Even more notably, 58% indicated that they would have felt comfortable if clinicians were to reach out to them via social media as symptoms were emerging, and even more (67%) liked the idea of actually obtaining help or advice through social media. These findings are provocative, as they indicate that not only are individuals at risk of a psychotic relapse using social media, but they

use the internet as their primary source of information, share indicative information on their websites of choice and are open to efforts via social media to provide earlier care.

After identifying indicators of risk for relapse and help-seeking behaviour, the next goal is to actively implement this information in clinical and community settings to improve the care options available to patients based on trends in social media presence. One example of this type of research is the "CrossCheck", a mobile app designed to track illness progression and risk based on data provided by the patient, particularly through data on social media and mobile phones such as conversation frequency, duration, and turn-taking, level of activity and sleep duration. A depiction of the progression using the app is depicted in Figure 3.

With this information, the app is able to tailor interventions based on the data that the patient generates organically. From these data, the patient can receive personalised feedback, mobile interventions, and even prompts to make contact with care providers. Similarly, the patient's treatment team can receive important information about the need for specific interventions, including outreach visits, medication alterations and other personalised services. Although this technology is still being refined and adapted to better serve the needs of patients, CrossCheck provides an excellent example of how social

media, mobile technology and traditional treatment methods can work together to improve the timing and quality of interventions for mental health issues such as psychosis.

Social Media and Mental Health: Looking to the Future

As the salience of social media continues to increase, it is essential that mental health providers, researchers and advocates continue to improve their understanding of how younger generations are using the internet to obtain information, communicate distress and seek help. The more challenging step, however, will be the implementation of this information in a useful, evidence-based manner. New apps such as CrossCheck (Ben-Zeev, Choudhury, Campbell, and Kane; study in progress) have started to address these challenges, but the larger challenge of gaining an increased access to actionable information is a daunting one. While traditional modalities such as community education, stigma reduction campaigns and clinician training will remain crucial areas of advancement, it is equally important that future research and treatment options acknowledge the growing importance of internet-based interventions and informational resources, especially those rooted in popular social media outlets.

Figure 3. Diagram of the CrossCheck mobile application
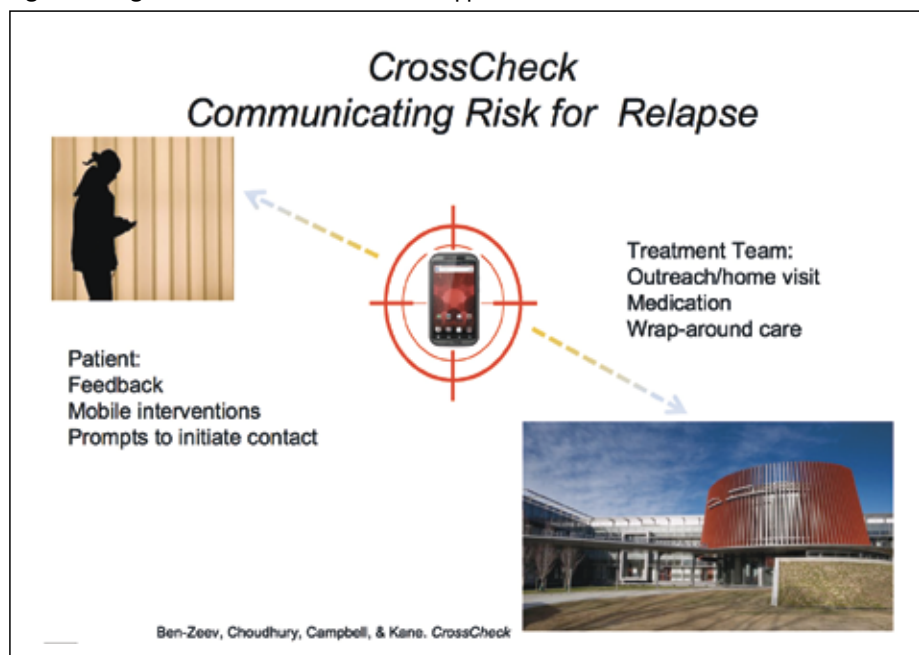
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Mobile technologies in neurology and psychiatry:

A revolution from research to treatment

Mobile technologies are transforming the way that researchers and clinicians collect information, interact with patients and identify salient issues.

As of 2014, the number of devices connected to mobile networks surpassed the total population of the planet (Boren, 2014). In the last couple of decades, technological advancement has become an indispensable aspect of nearly every market, with new innovations entering the market at a blistering pace. Projects utilising brain imaging and genetics have offered important insights for researchers with the hope that these areas of investigation can dramatically alter the way in which clinicians understand and treat patients. In lieu of these technological advances, however, which are often expensive and offer little in the way of providing specificity in regard to treatment, mobile technologies may offer more direct options to improve patient care, giving both clinicians and researchers access to data and interventions that might not otherwise be possible. In particular, cell phone applications, affordable video calling and wearable technology have emerged as areas of important research and development.

Mobile Technology in Research

Typical research studies relying on in-office visits with clinician-administered and patient self-report measures suffer from several limitations, including difficulty in directly testing disease phenomena, the short duration between risk factor exposure and the expression of many psychiatric symptoms, challenges in assessing the full spectrum of a disease and potentially limited ecological validity of many findings. During a typical research study, patients would complete regular visits during which they would provide an update on symptoms, problems and other associated information over periods of weeks to months. This method of data collection is, by the nature of the modality, limited. Without assessments over shorter time durations and a more continuous assessment of symptoms, the full spectrum of psychopathology is often neglected due to temporal barriers and arbitrarily high thresholds. This problem is illustrated by the existing research on bipolar disorder and stress, a notable risk factor for relapse into manic episodes. The great majority of publications demonstrating this link has focused on extreme, but rare, life events (divorce, death of a loved one, losing one's job) and symptom expression levels that fulfil diagnostic criteria for an 'episode'. Far less information is available concerning the more minor, but highly frequent, events of daily life and the expression of subthreshold symptomatology. In addition, while patients may be able to recall some information about clinical variables associated with relapse for different disorders, the accuracy of these data could be limited by numerous variables, including the patient's memory, selective attention or unawareness of risk factors (Stone et al., 1998). A further example of barriers characterising traditional clinical research can be found in studies of substance use comorbidity. Prior research has shown a notable correlation between alcohol use disorders and depression/anxiety, and some researchers have gone on to suggest that this association can be explained by a self-medication model, whereby patients abuse alcohol to help manage symptoms of depression and anxiety (Connor et al., 2009; Conway et al., 2006). However, without prospective data capable of linking fluctuations in emotional states with alcohol use in the subsequent minutes or hours, it is not possible to directly determine the veracity of a self-medication model underlying these forms of comorbidity. In order to more directly and accurately assess the true nature of a disease as it manifests itself throughout the day to day activities of an individual, it is clear that one must be able to ascertain what is happening in real-time (and between office visits). An advance which may permit such tracking in this area is ecological momentary assessment (EMA), which utilises electronic devices that permit ambulatory collection of data across
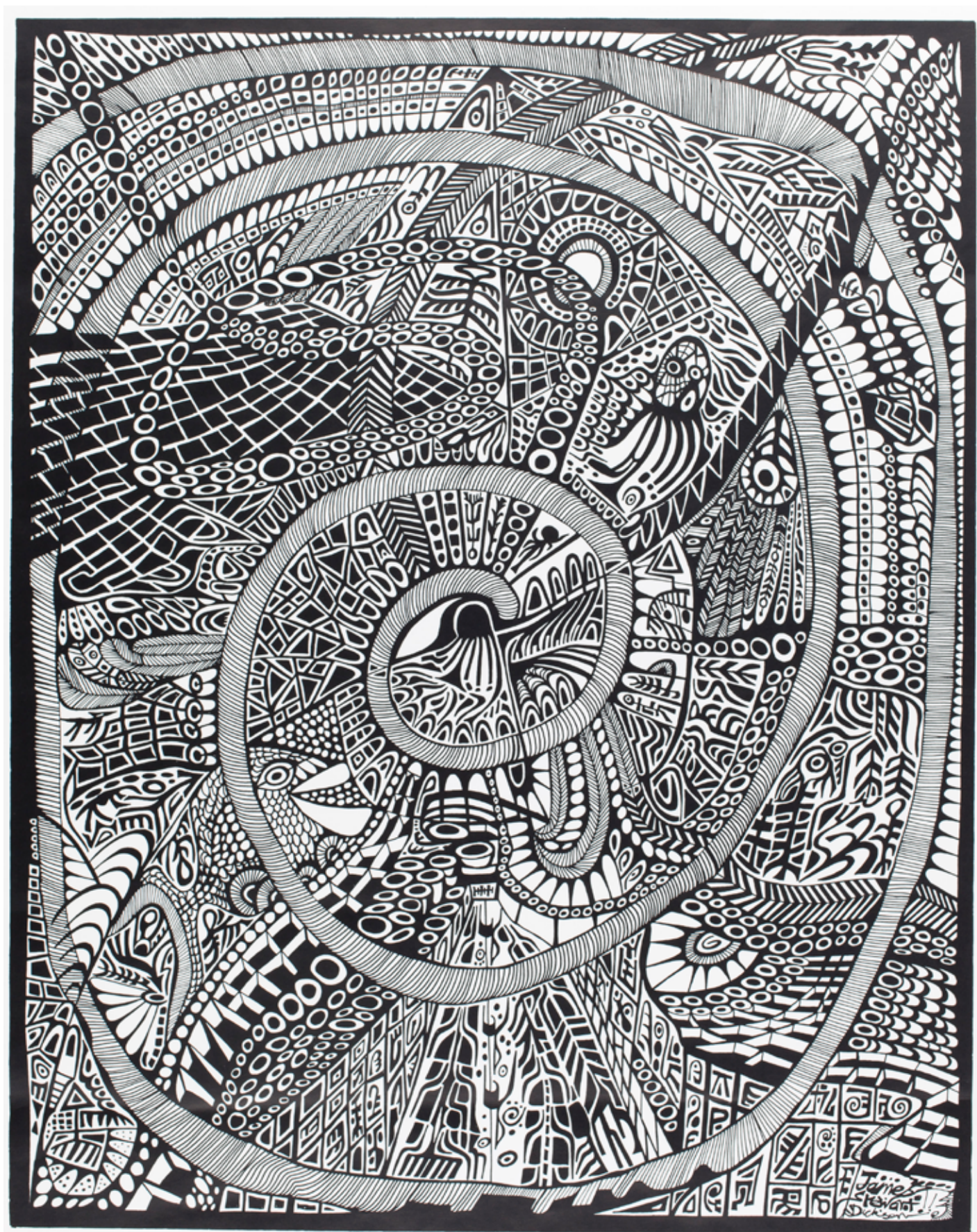
James Dickson, *The Abalone*, 1981.

Figure 1. Feasibility and reactivity results for studies using Ecological Momentary Assessment (EMA)

Feasibility	Healthy Controls n = 280		Anxiety Disorders n = 45		Schizophrenia n = 56		Substance Use Disorders n = 85		Mood Disorders n=42	
Acceptability	93%		89%		96%		98%		90%	
Material loss	2%		0%		2%		0%		0%	
Response rate	83%		73%		69%		80%		86%	
Reactivity	γ	SE	γ	SE	γ	SE	γ	SE	γ	SE
Fatigue Effect	0.03	0.03	0.02	0.05	-0.04	0.05	0.03	0.03	0.01	0.02
Training Effect	-0.18	0.03**	-0.28	0.05**	-0.31	0.04**	-0.13	0.03**	-0.12	0.02**

* .01

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Serre F, Auriacombe M, Fatseas M, Swendsen J. *Drug and Alcohol Dependence*, 2012; 126: 118-23.

Figure 2. Example interface from an ecological momentary assessment application (EMA), similar to that used for a study of schizophrenia treatment utilization
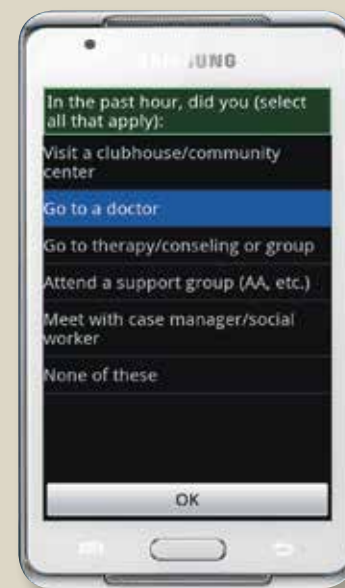
numerous time points throughout a day (Schwartz & Stone, 1998). Through ambulatory data collection, it is possible to obtain a more representative sample of behaviours, thoughts and emotions in more natural situations, rather than laboratory settings. With EMA, it is possible to more closely monitor the specific precipitating variables prior to a target event, such as a panic attack or substance use. The ability to track and log emotional and cognitive states continuously makes it easier to identify causal relationships, compared to the use of traditional interview and self-report methods. Furthermore, by assessing target variables in a more individualised manner, there is a greater likelihood of identifying specific endophenotypes within given diagnostic categories, which in turn may help improve both treatment and prevention efforts.

While EMA techniques using mobile technology are relatively new, initial studies have shown this approach to be highly feasible and valid across studies, both with healthy controls and patients with a variety of psychiatric disorders, including anxiety, schizophrenia, substance abuse disorders and mood disorders. Response rates for these studies were also promising, with overall rates ranging from 73-83 % (Granholm et al., 2008; Johnson et al., 2009a; Johnson et al., 2009b; Husky et al., 2010; Serre et al., 2012). Similarly, there were few issues related to app fatigue and training effects, which are promising indicators of reactivity for such mobile technologies. Basic findings on feasibility and reactivity from these studies are summarised in Figure 1.

Given these promising methodological findings, EMA has already shown direct applications in the field of neurology and psychiatry. One study conducted by Swendsen and colleagues (2011) used EMA conducted with mobile devices to assess potential relationships between alcohol/illicit drug use and precipitating symptoms in a sample of patients with schizophrenia. With the implementation of EMA, researchers were able to directly, and successfully, assess the interaction of these variables in a more representative manner, allowing patients to respond in a natural environment, rather than an office setting. Rather than providing evidence of self-medication (whereby the presence of hallucinations or delusions lead to cannabis use), a strong unidirectional association was found in the opposite direction in that cannabis use provoked new psychotic symptoms over subsequent hours. Another study assessing cue exposure in drug and alcohol craving used a similar methodology, using EMA to assess 160 patients in treatment for alcohol, heroin, cannabis or nicotine dependence (Fatseas et al., 2015). The study was similarly able to assess both personal and universal level cues that predicted cravings, a notable factor when considering risk of relapse. This insight is important as it allows researchers and clinicians to address patient populations on two distinct levels: the unique person-specific risk factors and the general population-specific risk factors. In particular, gaining access to data regarding individual cues and predictors may have substantial implications for timely clinical interventions and for the way in which treatment is personalised to the individual needs of a particular patient.

Mobile Treatment Interventions

In addition to research, mobile applications (hereafter "apps") also offer new treatment options for patients that may not otherwise be able to visit a psychiatrist, psychologist or other mental health professionals. In recent years, several digital apps have been developed, offering patient-friendly tools such as schedule tracking, appointment reminders, medication reminder alerts and other daily functions related to healthcare provision. More advanced apps, however, move beyond these uses. One example is the Personalized Real-Time Intervention for Stabilizing Mood (PRISM) (Depp et al., 2015), an app that sought to assess unique situational characteristics of patients and offer personalised reminders and interventions that are not available when using standard paper-pencil mood tracking. The initial study on PRISM assessed its utility in a sample of patients with bipolar disorder. The study assigned patients to one of two programs, involving a baseline of 4 in-person sessions and then 12 weeks of either mobile phone responses with PRISM, or 12 weeks of paper-pencil mood charts. The mobile intervention option provided the extra benefit of reminders regarding therapeutic strategies, and even offered guidance in personalised "messages to self" for patients. This combined method using PRISM and in-person sessions appeared successful, and patient response was significantly better than placebo. Such apps can be simplified to collect healthcare information and provide supportive interventions for even the most seriously impaired clinical populations, including schizophrenia. A generic example of the input for this type of app is shown in Figure 2.

Like all technology, however, these accessible mobile interventions are not without risks. Although the FDA has begun regulating different apps to some extent, given the sheer volume and rapid expansion of available apps to the market, it is simply not possible to monitor all of the apps available online and through mobile carriers. This limitation means that it is difficult to ensure the quality and veracity of a given app. In addition, the issue of data security is a salient concern, as evidenced in the recent number of data breaches that have impacted even large companies with heavy IT security systems in force. Whenever private patient information is involved, there is an increased need for data protection and additional security measures. Given the diffi-culty in regulating apps in this area, both consumers and clinicians need to be particularly diligent in assessing the quality of a mobile intervention, particularly if it will be used in conjunction with private health information.

Another potential issue may be the undesirable consequences of app use for standard care. Although mobile apps can provide select clinical interventions, it is not possible to deliver the full services that are available when meeting directly with a mental health professional. In particular, there is some concern that increased access to these mobile interventions may reduce the numbers of patients who seek in-person help from a qualified mental health professional. While this does not suggest that there will be a sudden decline in patients seeking help for mental health issues, it is crucial to ensure that patients do not settle for what may be insufficient mental health treatment, simply because it is more convenient than seeing professional. It is not yet known, however, whether this concern is supported empirically, as no studies to date have assessed the likelihood of this problem arising.

Conclusions

Mobile technologies have already begun to reshape the way that clinicians and researchers collect information, interact with patients and identify salient issues. New apps and assessment modalities have demonstrated the utility of this branch of technology and the generally positive impact it may have on the field of mental health. It should be noted, however, that while these technologies do offer new avenues of assessment and intervention, the number of available randomised, controlled studies using these apps remain limited. As research continues to assess the utility of mobile and digital apps in various facets of healthcare prevention and provision, it will be important to assess the quality, accessibility and security of new technology that becomes available for research and clinical settings.

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NEG, *Untitled*, undated.
'Black humour is a good defence: if you don't laugh you'll cry, the choice is easy. It's the crying escapes me.
Bereft: The timeline of grief takes no account of age or readiness. It's the place that never heals, or at best only heals over and opens up, gaping wide again if the circumstances decree. Three losses at once and the rest come back to haunt. Too much for this twit's heart....
Like when my sister-in-law took me to see the work of an acquaintance who had won the RHS Medal for Botanical Art. It was love at first sight. Such beauty. I just stood there, in front of those paintings caught up, and my mouth hanging open. You know what it's like. You do.
Just listen to Allegri's 'Misere'.'