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Cognitive Systems
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Research outputs:

Differences in mood instability in patients with bipolar disorder type I and II: a smartphone-based study

Background: Mood instability in bipolar disorder is associated with a risk of relapse. This study investigated differences in mood instability between patients with bipolar disorder type I and type II, which previously has been sparingly investigated.

Methods: Patients with bipolar disorder type I (n = 53) and type II (n = 31) used a daily smartphone-based self-monitoring system for 9 months. Data in the present reflect 15,975 observations of daily collected smartphone-based data on patient-evaluated mood.

Results: In models adjusted for age, gender, illness duration and psychopharmacological treatment, patients with bipolar disorder type II experienced more mood instability during depression compared with patients with bipolar disorder type I (B: 0.27, 95% CI 0.007; 0.53, p = 0.044), but lower intensity of manic symptoms. Patients with bipolar disorder type II did not experience lower mean mood or higher intensity of depressive symptoms compared with patients with bipolar disorder type I.

Conclusions: Compared to bipolar disorder type I, patients with bipolar disorder type II had higher mood instability for depression. Clinically it is of importance to identify these inter-episodic symptoms. Future studies investigating the effect of treatment on mood instability measures are warranted. Trial registration NCT02221336.

General information

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Personalized versus generic mood prediction models in bipolar disorder

A number of studies have been investigating the use of mobile phone sensing to predict mood in unipolar (depression) and bipolar disorder. However, most of these studies included a small number of people making it difficult to understand the feasibility of this method in practice. This paper reports on mood prediction from a large (N=129) sample of bipolar disorder patients. We achieved prediction accuracies of 89% and 58% in personalized and generic models respectively. Moreover, we shed light on the "cold-start" problem in practice and we show that the accuracy depends on the labeling
strategy of euthymic states. The paper discusses the results, the difference between personalized and generic models, and the use of mobile phones in mental health treatment in practice.

**Objective smartphone data as a potential diagnostic marker of bipolar disorder**

Currently, the diagnosis in bipolar disorder relies on patient information and careful clinical evaluations and judgements with a lack of objective tests. Core clinical features of bipolar disorder include changes in behaviour. We aimed to investigate objective smartphone data reflecting behavioural activities to classify patients with bipolar disorder compared with healthy individuals. Objective smartphone data were automatically collected from 29 patients with bipolar disorder and 37 healthy individuals. Repeated measurements of objective smartphone data were performed during different affective states in patients with bipolar disorder over 12 weeks and compared with healthy individuals. Overall, the sensitivity of objective smartphone data in patients with bipolar disorder versus healthy individuals was 0.92, specificity 0.39, positive predictive value 0.88 and negative predictive value 0.52. In euthymic patients versus healthy individuals, the sensitivity was 0.90, specificity 0.56, positive predictive value 0.85 and negative predictive value 0.67. In mixed models, automatically generated objective smartphone data (the number of text messages/day, the duration of phone calls/day) were increased in patients with bipolar disorder (during euthymia, depressive and manic or mixed states, and overall) compared with healthy individuals. The amount of time the smartphone screen was 'on' per day was decreased in patients with bipolar disorder (during euthymia, depressive state and overall) compared with healthy individuals. Objective smartphone data may represent a potential diagnostic behavioural marker in bipolar disorder and may be a candidate supplementary method to the diagnostic process in the future. Further studies including larger samples, first-degree relatives and patients with other psychiatric disorders are needed.
Reducing the rate and duration of Re-ADMISsions among patients with unipolar disorder and bipolar disorder using smartphone-based monitoring and treatment - the RADMIS trials: Study protocol for two randomized controlled trials

Background: Unipolar and bipolar disorder combined account for nearly half of all morbidity and mortality due to mental and substance use disorders, and burden society with the highest health care costs of all psychiatric and neurological disorders. Among these, costs due to psychiatric hospitalization are a major burden. Smartphones comprise an innovative and unique platform for the monitoring and treatment of depression and mania. No prior trial has investigated whether the use of a smartphone-based system can prevent re-admission among patients discharged from hospital. The present RADMIS trials aim to investigate whether using a smartphone-based monitoring and treatment system, including an integrated clinical feedback loop, reduces the rate and duration of re-admissions more than standard treatment in unipolar disorder and bipolar disorder. Methods: The RADMIS trials use a randomized controlled, single-blind, parallel-group design. Patients with unipolar disorder and patients with bipolar disorder are invited to participate in each trial when discharged from psychiatric hospitals in The Capital Region of Denmark following an affective episode and randomized to either (1) a smartphone-based monitoring system including (a) an integrated feedback loop between patients and clinicians and (b) context-aware cognitive behavioral therapy (CBT) modules (intervention group) or (2) standard treatment (control group) for a 6-month trial period. The trial started in May 2017. The outcomes are (1) number and duration of re-admissions (primary), (2) severity of depressive and manic (only for patients with bipolar disorder) symptoms; psychosocial functioning; number of affective episodes (secondary), and (3) perceived stress, quality of life, self-rated depressive symptoms, self-rated manic symptoms (only for patients with bipolar disorder), recovery, empowerment, adherence to medication, wellbeing, ruminations, worrying, and satisfaction (tertiary). A total of 400 patients (200 patients with unipolar disorder and 200 patients with bipolar disorder) will be included in the RADMIS trials. Discussion: If the smartphone-based monitoring system proves effective in reducing the rate and duration of readmissions, there will be basis for using a system of this kind in the treatment of unipolar and bipolar disorder in general and on a larger scale.

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Voice analysis as an objective state marker in bipolar disorder
Changes in speech have been suggested as sensitive and valid measures of depression and mania in bipolar disorder. The present study aimed at investigating (1) voice features collected during phone calls as objective markers of affective states in bipolar disorder and (2) if combining voice features with automatically generated objective smartphone data on behavioral activities (for example, number of text messages and phone calls per day) and electronic self-monitored data (mood) on illness activity would increase the accuracy as a marker of affective states. Using smartphones, voice features, automatically generated objective smartphone data on behavioral activities and electronic self-monitored data were collected from 28 outpatients with bipolar disorder in naturalistic settings on a daily basis during a period of 12 weeks. Depressive and manic symptoms were assessed using the Hamilton Depression Rating Scale 17-item and the Young
Mania Rating Scale, respectively, by a researcher blinded to smartphone data. Data were analyzed using random forest algorithms. Affective states were classified using voice features extracted during everyday life phone calls. Voice features were found to be more accurate, sensitive and specific in the classification of manic or mixed states with an area under the curve (AUC) = 0.89 compared with an AUC = 0.78 for the classification of depressive states. Combining voice features with automatically generated objective smartphone data on behavioral activities and electronic self-monitored data increased the accuracy, sensitivity and specificity of classification of affective states slightly. Voice features collected in naturalistic settings using smartphones may be used as objective state markers in patients with bipolar disorder.

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**Projects:**

**Machine learning for smartphone-based monitoring and treatment of unipolar and bipolar disorders**
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Winther, O., Main Supervisor
Bardram, J. E., Supervisor
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