

Forecasting mood in bipolar disorder

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- Introduction
 - Bipolar disorder, the database and how the data was collected
- Data characteristics and cleaning
 - Summary statistics and cleaning criteria
- Forecasting
 - Using exponential smoothing and Gaussian process regression
- Effects of gender on mood predictability

Bipolar Disorder

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People with bipolar disorder suffer extremes of depression and mania. Depression can mean persistent unhappiness, loss of appetite and problems with sleep, while mania sometimes leads to poor choices: gambling, spending sprees and sexual indiscretions. The disorder often affects creative people - among them, the mathematician Georg Cantor.



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Diagnostic subtypes of bipolar disorder

- **Bipolar I.** At least one manic episode. Depression may or may not occur.
- **Bipolar II.** At least one major depressive episode with accompanying hypomania.
- **Cyclothymia.** A history of hypomania and non-major depression.
- **Bipolar NOS.** Symptoms of mania and depression which do not fit into any categories above.

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<i>Inventory Category</i>	<i>Domain Score (0-3)</i>
1. Sleep (<i>4 questions</i>)	
2. Feeling sad	
3. Appetite/weight (<i>4 questions</i>)	
4. Concentration	
5. Self-view	
6. Death/suicide	
7. General interest	
8. Energy level	
9. Slowed down/Restless (<i>2 questions</i>)	

The QIDS Scale for depression: domains and symptoms. There is more than one question for domains 1, 3 and 9, so there are 16 questions in total. The score in these cases is calculated by taking the maximum score over all questions in the domain. The total score is the sum of the domain scores.

Measuring Mania

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<i>Inventory Category</i>	<i>Item Score (0-4)</i>
1. Feeling happier or more cheerful than usual	
2. Feeling more self-confident than usual	
3. Needing less sleep than usual	
4. Talking more than usual	
5. Being more active than usual	

The Altman self-rating mania scale. Each question can score from 0 – 4 giving a maximum possible score of 20.

Monitoring Mood in Bipolar disorder

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A mood monitoring system



Please send your mood ratings



D 2230220120331121

M 002211



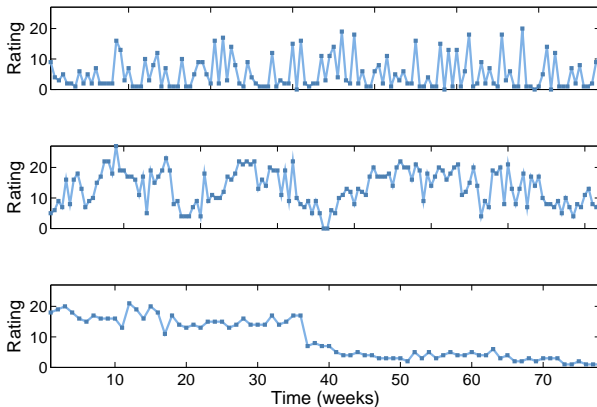
Since 2006, the Department of Psychiatry in Oxford has been monitoring mood in patients with bipolar disorder by using SMS text messages to return questionnaire results. Each week, participants return two numbers representing the depression and mania scores.

The resulting database now holds mood ratings for more than 400 patients over 5 years.

Example Depression Time Series

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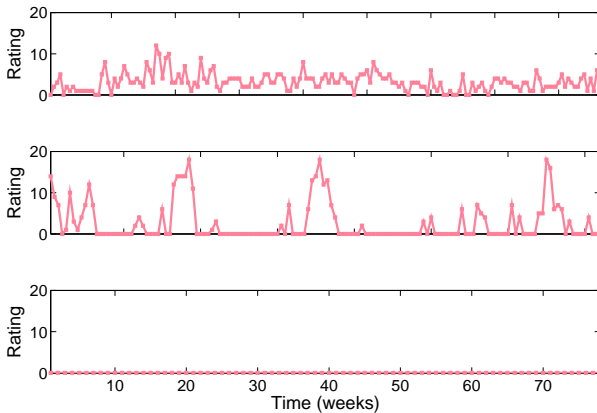
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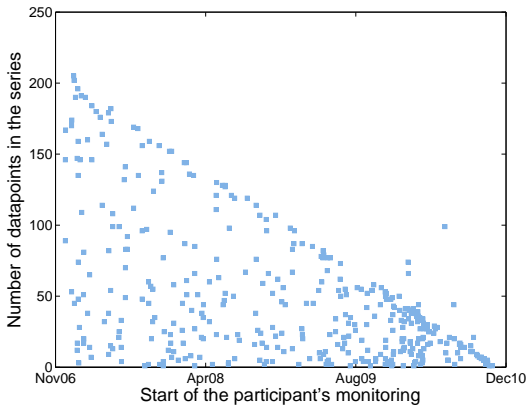
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Time Series Lengths



Number of data points in each patient's time series. The maximum length usually depends on when the patient joined the monitoring scheme. The outliers are patients who return data more frequently than every week.

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Histogram of
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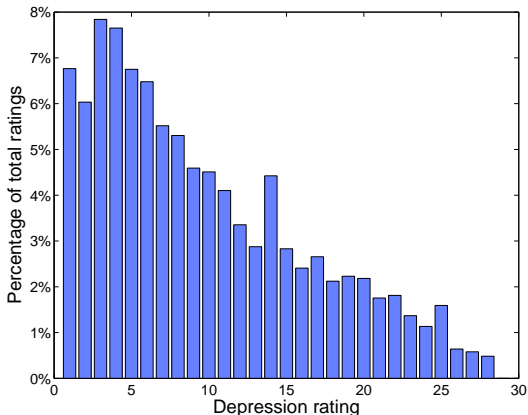
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Histogram of Depression Ratings

Histogram of Depression Ratings



Histogram of depression ratings pooled over all patients.

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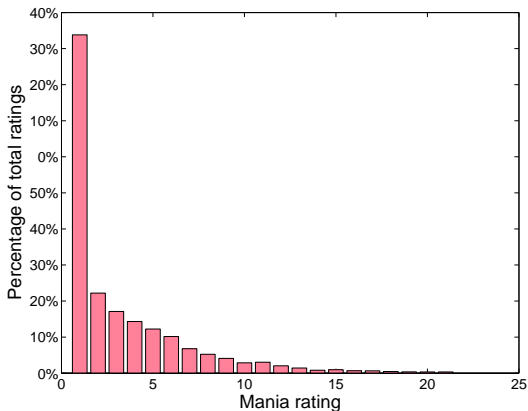
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Histogram of Mania Ratings



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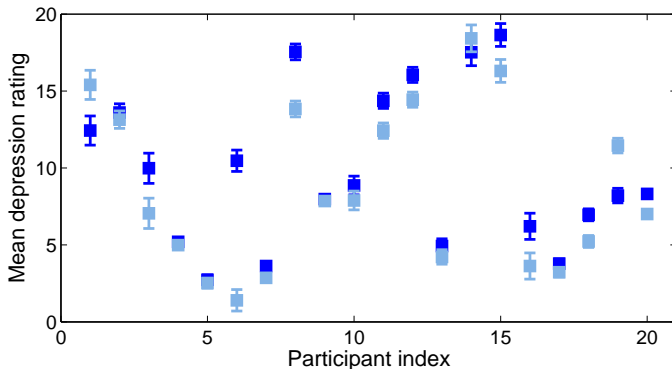
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Non Stationarity of Time Series



Dark blue and light blue markers represent the sample mean of the first and second halves of the depression time series for 20 patients. The error bars represent the standard error assuming that the numbers are Gaussian distributed and uncorrelated.

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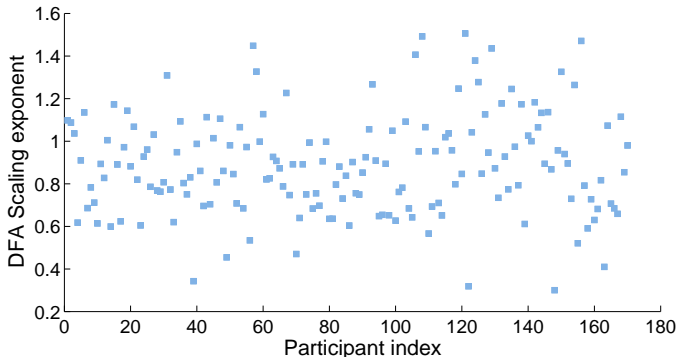
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Scaling Exponents



The scaling exponent is derived from detrended fluctuation analysis (DFA) for each of the time series in a cleaned data set. It can be seen that the data set is heterogeneous.

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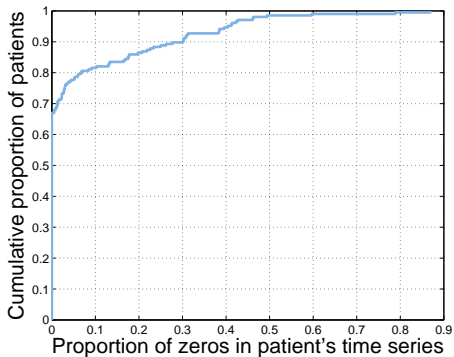
**Proportion Of
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Empirical cumulative probability density of the proportion of zeros in the depression time series of patients with a least 30 data points.

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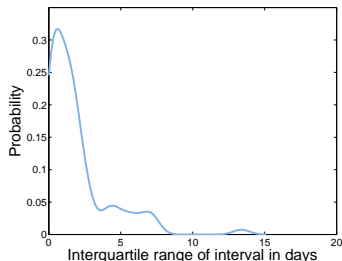
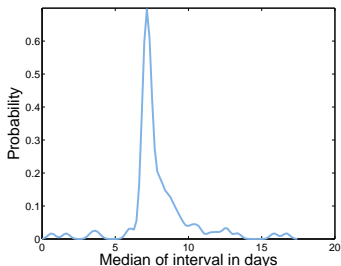
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Median and interquartile range of the intervals between responses for all patients with time series of at least 70 points. The distributions are estimated using a Gaussian kernel at 100 evenly spaced points.

Selection Criteria

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<i>Filter criterion</i>	<i>Condition (units in days)</i>	<i>Failed</i>
Minimum observations	$N_{obs} \geq 70$	28
Maximum zero ratings	$N_{zeros} \leq 0.3N_{obs}$	24
Median/IQR of interval	$6 \leq med \leq 9, iqr \leq 3$	189

Filter criteria for selecting the data set for forecasting. A given time series may fail more than one condition, so for example many short series with fewer than 70 points also fail the condition for the response statistics. Starting with 397 participants, 61 are left after the filtering process is complete.

Exponential Smoothing

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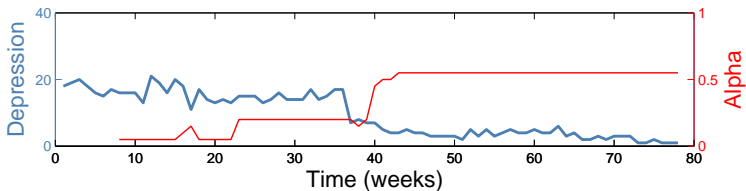
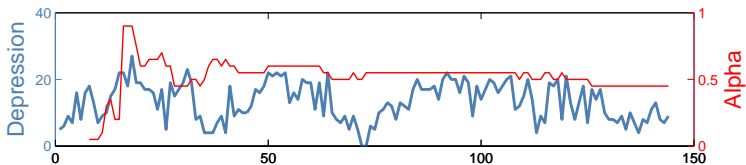
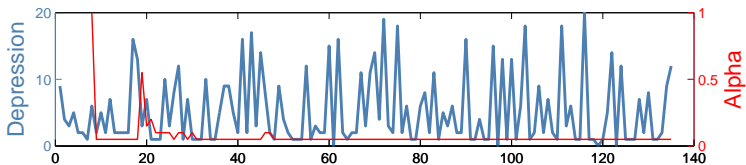
Forecast Results

Gender
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Summary

- Self esteem has been found to be modelled using simple exponential smoothing $\hat{y}_{t+1} = \hat{y}_t + \alpha(y_t - \hat{y}_t)$ (Fortes, *Dynamics of Self-Esteem and Physical Self, Quality and Quantity*, 2004).
- They suggest that two processes underlie the dynamics of self-esteem: *preservation* which tends to restore the previous value after a disturbance and adaptation, which tends to inflect the series in the direction of the perturbation
- The disturbance (or shock) can be seen as the result of all the good and bad events (known in psychology as *stressors*). The value of α might then provide a measure of the preservation/adaptation spectrum.

Parameter Stability



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- For a Gaussian Process the joint distribution between any finite number of these variables is Gaussian. The process is specified by a mean function and a covariance function.
- We postulate a certain form of parameterised covariance function and estimate the parameters from the data.
- The expected value and variance of the function can then be found for any input.

Forecasting Evaluation

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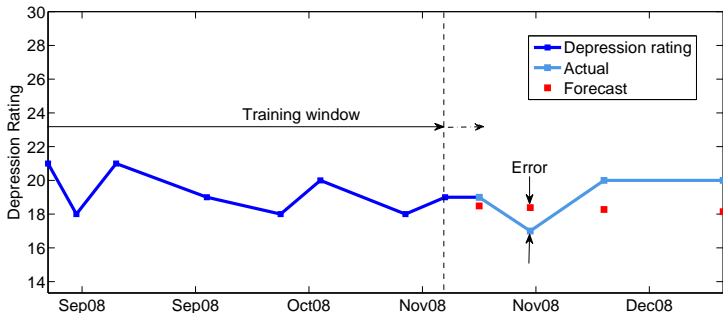
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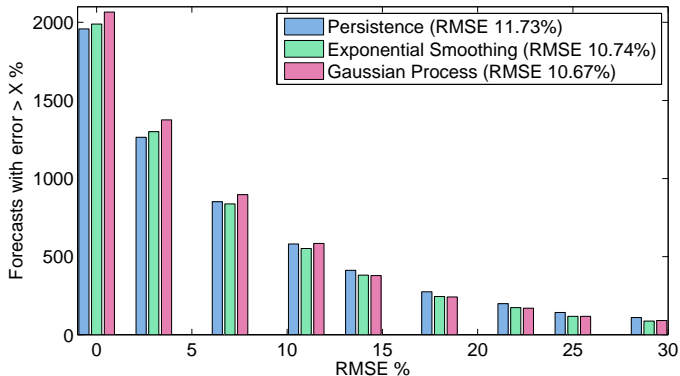
Summary



For each time series, a window is extended stepwise from a minimum offset to a maximum length. At each point a next step forecast is made. This process is repeated for all patients, and the root mean square error taken over all forecasts.

Forecasting Results

Cumulative error distribution



The figure shows the cumulative error distribution for 2440 forecasts. The X axis is the forecast error normalised by the maximum of the rating scale. There is little to choose between the methods, except that the nontrivial methods reduce higher errors slightly compared with persistence forecasting.

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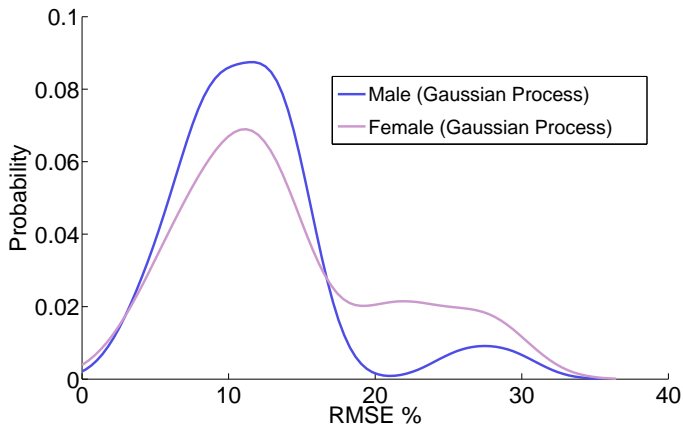
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Gender Differences

Forecast error distributions for male and female patients



Kernel density estimation for distribution of forecast errors for two sets of 30 patients, one all male and the other all female ($p = 0.02$). The x-axis is the normalised RMS forecast error for a participant over a test set.

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Summary of work presented

- The mood dataset is heterogeneous with a wide variety of length, range and response statistics.
- Exponential smoothing and Gaussian process forecasting offer little improvement over persistence forecasts for depression.
- A difference was found in the forecast error between sets of male and female patients.