Intervention, outcome measure or self-management tool: mood & activity monitoring in clinical studies

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Seminar 5: Diaries and intensive longitudinal data in intervention designs.
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• Mood monitoring in mental health
• Intervention
• Outcome measure
• Self-management
• Low friction data capture
Figure 1.43
Smartphone ownership, by age: 2012-2015

Proportion of adults (%)

Source: Ofcom Technology Tracker. Data from Quarter 1 2012-2013, then Wave 1 2014-2015.
Base: All adults aged 16+ (2015 n=3756).
Q04/QQ24B: Do you personally use a smartphone?
Mobile Health User Stats

- Male: 54%
- Have a smartphone: 87%
- Own an iPhone: 33%
- Downloaded a mHealth app: 61%
- Use social media for health: 85%
- Take Rx: 76%
- Caregivers: 30%

Among online U.S. adults ages 18+
Source: Manhattan Research, Cybercitizen Health® U.S. 2011
Android Wear
Smartphone-out

Apple HealthKit
Wearables-in

Wearables extend smartphone functions out

Wearables feed smartphone functions.

Jackdaw Research, 2014
Gathering of information about mood symptoms and activity is traditionally based on questionnaires and clinical interviews...

Inherent bias of retrospective mood recall
Increase in the sophistication and accessibility of technology provides a platform for remote data collection of mood and activity.

- Data is collected prospectively
- Data can be collected longitudinally
True Colours

SELF-MANAGEMENT SYSTEM
Each week you receive a prompt to fill in two short questionnaires.

You complete one questionnaire about depression symptoms and one about mania symptoms.

Your scores are logged on a graph which keeps a track of your mood scores over time.
Mood dynamics in bipolar disorder

Paul J. Moore, Max A. Little, Patrick E. McSharry, Guy M. Goodwin and John R. Geddes

Correlates of depression in bipolar disorder

Paul J. Moore, Max A. Little, Patrick E. McSharry, Guy M. Goodwin and John R. Geddes

Forecastsing Depression in Bipolar Disorder

Paul J. Moore*, Max A. Little, Patrick E. McSharry, Senior Member, IEEE, John R. Geddes, and Guy M. Goodwin
Some simple analyses...mean mood ratings

Tsanas et al in press

Weekly ratings (True Colours)

BPD participants reported higher levels of depression and anxiety than BD participants, as rated weekly.

Daily ratings (Mood Zoom)

In daily ratings, BPD participants reported greater anxiety, sadness and irritability compared to BD.
Looking at measures of mood instability...
- Weekly mood ratings

TKEO: used to identify patterns in the longitudinal mood data.
- Measures the difference between the previous data point and the data point that follows, in order to understand a data point in its context.
- It measures the frequency and amplitude of the signal.

BPD participants demonstrate greater variability in weekly QIDS (depression) and GAD-7 (anxiety) ratings than BD and ‘healthy controls.’

There was no difference in the variability of ALTMAN (mania) ratings between groups.
Comparative evaluation of quetiapine plus lamotrigine combination versus quetiapine monotherapy (and folic acid versus placebo) in bipolar depression (CEQUEL): a 2 × 2 factorial randomised trial

Prof John R Geddes, MD, Alexandra Gardiner, BSc, Jennifer Rendell, DPhil, Merryn Voysey, MBiostat, Elizabeth Tunbridge, DPhil, Christopher Hinds, DPhil, Ly-Mee Yu, MSc, Jane Hainsworth, BSc, Mary-Jane Attenburrow, MRCPsych, Prof Judit Simon, DPhil, Prof Guy M Goodwin, FMedSci, Prof Paul J Harrison, DM on behalf of the CEQUEL Investigators and Collaborators†
Psychoeducation and Online Mood Tracking for Patients with Bipolar Disorder: A Randomised Controlled Trial  (Bilderbeck et al unpublished)

• FIMM versus MIMM

• 5 psychoeducational sessions

• Manualized psychoeducation

• Aim was to explore self-directed versus therapist-facilitated psychoeducation in BD
The intervention

• True Colours remote monitoring system
• 5x50-min. individual sessions with a facilitator v manual only
• Psychoeducational manual
  • (1) identifying the relapse signature;
  • (2) reviewing risk and protective factors;
  • (3) daily rhythm and sleep/wake regulation;
  • (4) the role of medications and substance/alcohol abuse;
  • (5) finalising the mood management plan.
• No group differences in depression scores
• No differences in relapse or readmission
• Greater illness knowledge at 3 months was related to a higher proportion of weeks well over the 12 month study period.
Differences in depressive symptoms (HAMD-17 score) between the intervention group (−x−) and the control group (−●−) over 6 months (adjusted for HAMD-17 at baseline, previous hospitalization yes/no, age ≥29 or <29 years and sex), n = 67

Farhoul-Jepsen et al 2015
Is mood monitoring an intervention per se?
What do patients think?
Compliance for mood ratings

Data processed from all 130 participants - up to date as of 13th January 2016

True Colours questionnaires - 7,417 unique weekly mood samples
Mood Zoom questionnaire - 37,521 unique daily mood samples

Boxplots presenting compliance for each of the three groups for weekly and the daily questionnaires. The red line is the median compliance.
Insight

The majority of participants highlighted how monitoring their mood had been useful in enabling them to identify how they were feeling, and enhanced their understanding of their illness.

“I think it’s definitely made me more aware of how I’ve been feeling generally like the different fluctuations in my mood and variety and stuff like that which might have lessened some of the extremes that I couldn’t face the first time”

“It really, just, just raised self-awareness of my moods, how I manage them and my sleep.”
Insight – awareness in the moment

Participants noted how (once daily and 10 x daily) mood monitoring enables them to check-in with their mood, or reflect on it, throughout the day, overcoming some of the difficulties in “summarising” mood over longer periods.

“It has really helped with different goals that I have at therapy, at the moment there’s been able to recognise the differences between in the moment and long term and things like that. So it is really useful. It has really helped.”

“It didn’t bother me filling it in, I find it quite interesting to kind of pause and think for a second what my mood was actually like.”

“In many ways much easier to answer the questions to just kind of ‘This is how I’m feeling now this minute’ rather than have to generalise over the last day.”
From insight to behavioural change

Whilst mood monitoring together with activity monitoring wasn’t associated with substantial changes in behaviour, participants highlighted how identifying mood and mood fluctuations in itself led to an improvement.

“I think maybe I suppose it has other consequences than checking in with my emotions to realising that I was actually very irritable, sad or something and that I might try to actively do something to alleviate it or talk to someone and say hey I’m really feeling x y z”

“Because I was recording it I was actually acknowledging how I felt so by doing that I was able to try and do something that would make some of the anxiety go away or you know if I was struggling a bit with feeling down I would do something that would distract me...so I found it quite useful and I think that’s something that I might be able to carry on doing in the future.”
Validation

Many participants felt that viewing the physical data provided them with objective reasons and justifications for their feelings, thus enabling them to be more accepting of them.

“I think the big thing is that I always felt that I was being irrational when I feel these things whereas now I can kind of say ‘Well actually no I’m not being irrational it’s because of this and actually tomorrow if I get a better night’s sleep or I don’t eat so much or’ yes whatever then I can regulate it and put it back’.”

“There’s still times when I feel I’m excessively angry or I’m excessively sad or excessively paranoid... and it’s just I don’t know it’s just nice to feel there is something physical going on.”
Challenges with active data collection

- Interventions only work if people do them

- Participant compliance
  - Illness
  - Wellness
  - Irritation

- Reliance on self-report

- Knowing what questions to ask
Data Pre-Processing
Data Pre-Processing
<table>
<thead>
<tr>
<th>FEATURE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entropy (ENT)</td>
<td>Variability in time that is spent in different locations</td>
</tr>
<tr>
<td>Normalised entropy (NENT)</td>
<td>Entropy normalised for the number of location clusters</td>
</tr>
<tr>
<td>Location variance (LV)</td>
<td>Variance in recorded locations</td>
</tr>
<tr>
<td>Home stay (HS)</td>
<td>Percentage of time spent at home</td>
</tr>
<tr>
<td>Transition time (TT)</td>
<td>Percentage of time spent travelling</td>
</tr>
<tr>
<td>Total distance (TD)</td>
<td>Total distance travelled</td>
</tr>
<tr>
<td>Number of clusters (NC)</td>
<td>No of different locations visited</td>
</tr>
<tr>
<td>Diurnal movement (DM)</td>
<td>Measure of daily regularity</td>
</tr>
<tr>
<td>Diurnal movement on normalised coordinates (DMN)</td>
<td>DM where location coordinates are normalised to limit the impact of outliers</td>
</tr>
<tr>
<td>Diurnal movement on distance from home (DMD)</td>
<td>DM normalised to minimise the impact of direction.</td>
</tr>
</tbody>
</table>
Optimised Feature Values

Normalized Entropy (weekdays)

QIDS Score

Normalized Entropy (weekdays)

Optimised Feature Values

Normalized Entropy (weekdays)

QIDS Score

Home Stay (weekdays)

Optimised Feature Values

Normalized Entropy (weekdays)

QIDS Score

Home Stay (weekdays)
Feature Statistics

Feature Statistics (HC vs. BD)

[Box plots showing feature statistics for HC (QIDS < 11) and BD (QIDS < 11) and BD (QIDS ≥ 11)]
Classification Results

6 Features: Accuracy = 0.847 (sensitivity = 0.839, specificity = 0.884)

Geolocation will identify accurately 83% of those who are depressed, and miss 11%
Individual Trends

• This representation is not very useful to actually understand how the features correlate with QIDS in individuals.

• Need to work with individuals separately.
Longitudinal Data (Raw)
Longitudinal Data (Kalman Filtered)
Classification on Kalman Filtered Data (Offline)
Classification on Kalman Filtered Data (Online)
Classification on Kalman Filtered Data (Offline)
Conclusions

• Smartphones are affordable and widely available
• Ubiquity of mobile phone coverage
• Wearables offer additional data streams
• Efficient means to collect and deliver data/interventions
Conclusions

• Enhance our understanding of psychiatric phenotypes
• Enhance clinical practice
  • Diagnosis
  • Treatment response
  • General well being
• Enhance patient’s understanding of their illness
• Highlight new treatment targets
• Within participant analyses likely to be most powerful
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Questions