Personalized predictions and clinical support tools based on big data: Development and implementation

Brian Schwartz & Wolfgang Lutz
University of Trier
Big Data in Psychology 2018
Trier, June 2018
Introduction

- About 5-10% of clients **deteriorate** during treatment (Lambert, & Ogles, 2004)

- The accuracy of predictions regarding treatment failure tends to be higher when relying on **statistical algorithms** rather than therapists’ judgements (e.g., Hannan et al. 2005; Hatfield, McCullough, Frantz, & Krieger, 2010; Lutz, Lambert, Harmon, Tschitsaz, Schürch, & Stulz, 2006)

→ **Early detection** of negative course as well as **adaption of treatment strategy** is indicated!
Until now, most medical treatments have been designed for the “average patient.” As a result of this “one-size-fits-all” approach, treatments can be very successful for some patients but not for others. **Precision Medicine** refers to the tailoring of medical treatment to the individual characteristics of each patient.

What is individually tailored mental health care?

- Robert DeRubeis et al. – University of Pennsylvania, Helena Kramer et al. – Stanford University
- Adam Checkroud et al. – Yale University, Ronald Kessler et al. – Harvard Medical School
- Jamie Delgadillo, Michael Barkham et al. – University of Sheffield, Aaron Fisher et al. – UC Berkeley
- Hanna van Loo et al. – University of Groningen, John Weisz et al. – Harvard University
- Steve Pilling et al. – University College of London

Different approaches with a similar aim

→ individualized patient predictions
Development and Current Implementation
Personalized predictions and adaptation

Grant no. LU 660-10/1
(Lutz, Zimmermann, Müller, Deisenhofer, & Rubel, 2017)
### Measures at the outpatient center Trier: Overview

#### First contact (registration)
- OQ-30
- Wellbeing - Patient
- IIP-46
- Perception of the self (INK-23)
- Emotionality (EMI-24)
- BSI
- General attitudes (DAS-K)
- Self efficacy (SE)
- Personal attitudes (PSSI-K)
- Life events (ILE)
- Sociodemographic facts
- Current Medication
- Questions regarding treatment expectations

#### Before the 1st session
The same questionnaires as after the registration!
Personalized treatment predictions and adaptive problem solving

1. Treatment recommendation before treatment
   • Which treatment is effective for this specific patient?
   • Should I make patient-specific adjustments to my interventions?

2. Treatment adaption during treatment
   • Is the current treatment successful for this patient?
   • Is this patient at risk for a negative treatment outcome?
Patient details for code: 9996P99

My patient overview / Patient list / Patient details

GAS

PERSONALIZED TREATMENT RECOMMENDATION

Treatment recommendation

To treatment recommendation

PERSONALIZED TREATMENT ADAPTION

Treatment recommendation

To treatment adaption

STATUS REPORT

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z 10</td>
<td>2014-12-01</td>
</tr>
<tr>
<td>Z 05</td>
<td>2014-10-01</td>
</tr>
<tr>
<td>PR</td>
<td>2014-08-01</td>
</tr>
<tr>
<td>WZ</td>
<td>2014-06-01</td>
</tr>
</tbody>
</table>

PROGRESS REPORT

<table>
<thead>
<tr>
<th>Last assessment</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z 10</td>
<td>2014-12-01</td>
</tr>
</tbody>
</table>

Progress
Patient details for code: 9996P99

- My patient overview / Patient list / Patient details

GAS

<table>
<thead>
<tr>
<th>PERSONALIZED TREATMENT RECOMMENDATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment recommendation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PERSONALIZED TREATMENT ADAPTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment recommendation</td>
</tr>
</tbody>
</table>

1. Therapy Expectation / Drop-Out
2. Personalized Treatment Prediction
3. Similar Patient-Therapist Dyads
Therapy Expectation / Drop-Out

**THERAPY EXPECTATION / DROP-OUT**

How confident are you that counseling or psychotherapy will be successful in helping you with your problem(s)? (TEW_3)

Estimated drop-out probability (%)

![Graph showing confidence levels and drop-out probability](image-url)
Therapy Expectation / Drop-Out

Analysis steps:

1. Archival data set of outpatients (N=1234) / drop-out = 22.6% (all = 29.9%)
2. 78 variables - bivariate correlations of the variables with drop-out → 31 significant variables
3. Bootstrap Ranking LASSO (BRLasso) (protection from overfitting) → 7 significant variables
4. Logistic regression with 7 significant predictors
## Results (weights) of BRLasso and logistic regression:

<table>
<thead>
<tr>
<th></th>
<th>BRLasso (all)</th>
<th>GLM</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEP-2</td>
<td>-0.230</td>
<td>-0.697</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>HSCL</td>
<td>0.261</td>
<td>0.609</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>PSSI – Subscale histrionic</td>
<td>0.322</td>
<td>0.359</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>OQ-30 – Subscale interpersonal relationships</td>
<td>0.411</td>
<td>0.530</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PSSI – Subscale obsessive-compulsive</td>
<td>-0.416</td>
<td>-0.320</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Therapist’s therapy expectation for the patient</td>
<td>-0.509</td>
<td>-0.513</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>High school education</td>
<td>-0.586</td>
<td>-0.610</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

*Estimated drop-out probability (%)*
Patient details for code: 9996P99

My patient overview / Patient list / Patient details

GAS

1. Therapy Expectation / Drop-Out
2. Personalized Treatment Prediction
3. Similar Patient-Therapist Dyads
Personalized Treatment Prediction

![Graph showing treatment prediction with categories: Problem-solving (n=27), Mixed (n=16), Motivation-oriented (n=30).]
**Personalized Treatment Prediction**

- Total N=1234; Groups: Problem-solving n=509, Mixed n=254, Motivation-oriented n=471

- **Problem-solving oriented approach** focused on working on concrete problem situations and options for action.

- **Relational and motivation-oriented approach** focused on establishing the therapeutic alliance, therapy goals and therapy motivation.

- Selection of (max. 30) nearest neighbors based on diagnostic category, HSCL-11 (± .15), treatment expectation, previous therapy and chronicity.

- Predicted variable: Effect size on OQ-30 (until session 10 in the three treatment alternatives).
Nearest Neighbor (NN) Approach

• Adapted from avalanche forecasting

• Improve predictions based on large databases by using only comparable cases (Lutz et al., 2005, 2006)
Nearest Neighbor (NN) Approach

Patient 1
Patient 2
Patient 3
Patient 4
Patient 5
Patient 6
Patient 7
Patient 8
Patient 9
Patient 10
...

Patient 11
Patient 12
Patient 13
Patient 14
Patient 15

Prediction 1a
Problem-solving orientation

Prediction 1b
Motivation orientation
Patient details for code: 9996P99

1. Therapy Expectation / Drop-Out
2. Personalized Treatment Prediction
3. Similar Patient-Therapist Dyads
Nearest neighbor patients for the purpose of supervision and intervision

- Selection of nearest neighbors on the basis of diagnosis, HSCL-11, therapy expectation, previous therapy and chronicity
- Selection of the 10 most similar patient-therapist-dyads with a positive therapy outcome.
Adaptive prediction model

1. Archival data set of outpatients with completed therapy ($N = 1234$)
2. At least one overlapping diagnostic category (e.g. Depression, Anxiety, etc.)
3. Deviation on HSCL-11 of $\leq \pm 0.15$ (half a SD)
4. A negative slope (meaning positive therapy progress)
5. Selection of the nearest 30 patients based on the predictors: HSCL-11, treatment expectation, previous therapy, chronicity and HSCL-11 change score (starting at session 5)
Adaptive prediction model
- Example

\[
OQTot_{ij} = \beta_{0j} + \beta_{1j} \text{Sessions}_{ij} + r_{ij}
\]
\[
\beta_{0j} = \gamma_{00} + \gamma_{01}(\#\text{Sessions}_{j} - \text{AMSess}. ) + e_{0j}
\]
\[
\beta_{1j} = \gamma_{10} + \gamma_{11}(\#\text{Sessions}_{j} - \text{AMSess}. ) + e_{1j}
\]

Consideration of treatment duration
Clinical support tools (CST)

When general symptom progress is not on track, the therapist is provided with five clinical support tools.

If the patient shows high values on one of the scales, then this scale is displayed in orange.

Areas, in which the patient’s problems remain under the clinical cut-off are marked green and are not accessible.
Therapy motivation is determined using the ASC. Each item is accessible to the therapist. Cut-off value $\leq 32$

### ASC SCALES

#### Therapy motivation

<table>
<thead>
<tr>
<th>Question</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>I wonder what I am doing in therapy; actually I find it boring</td>
<td>4</td>
</tr>
<tr>
<td>Honestly, I really don’t understand what I can get from therapy.</td>
<td>5</td>
</tr>
<tr>
<td>I am not really sure what to work on in therapy.</td>
<td>4</td>
</tr>
<tr>
<td>I had thoughts about quitting therapy; it’s just not for me.</td>
<td>5</td>
</tr>
<tr>
<td>I don’t think therapy will help me feel any better.</td>
<td>5</td>
</tr>
<tr>
<td>I have no desire to work out my problems.</td>
<td>4</td>
</tr>
<tr>
<td>Although I am currently unhappy with life, there is nothing I can do about it now.</td>
<td>4</td>
</tr>
<tr>
<td>Through therapy I am taking more responsibility for changing my life.</td>
<td>2</td>
</tr>
<tr>
<td>I am in therapy because someone is requiring it of me.</td>
<td>5</td>
</tr>
</tbody>
</table>
The tool is based on Schulte’s (2015) Promotion of Motivations Program as well as Motivational Interviewing (Rollnick) and was supplemented with elements from Barlow et al. (2011).
Excerpts of the problem-solving tools

Therapists are able to download different therapy material
Outlook
• **UK: MQ-Wellcome Trust Project:** Precision Medicine Data Tournament for Treatment Selection (Cohen, DeRubeis, Delgadillo), 13 teams, predictions for 6,000 patients in the IAPT- Program

• Training and validation of machine learning based prediction models (svm, nnet, random forest, bart machine, ..., ensemble learner)

• **Feedback Tool Trier:** Dynamic archival dataset, growing with each completed case
Improving dropout prediction

- Network analysis based on ecological momentary assessments

\[
\text{awake}_{pd(t)} = \gamma_{0pd} + \gamma_{1pd} \times \text{awake}_{pd(t-1)} + \gamma_{2pd} \times \text{excited}_{pd(t-1)} + \\
\gamma_{3pd} \times \text{ashamed}_{pd(t-1)} + \ldots + \gamma_{12pd} \times \text{self-efficacy}_{pd(t-1)} + \varepsilon_{pd}
\]

\[
\gamma_{kp} = \beta_{k} + b_{kp}
\]

- Proof-of-concept study (Lutz, Schwartz, Hofmann, Fisher, Husen, & Rubel, 2018)
Movement Synchrony

- Analysis of video-taped session recordings via Motion Energy Analysis and windowed cross-lagged correlations

Outcome, Dropout, early response (Paulick et al., 2017, 2018; Schwartz et al., in prep)
Discussion

• Stronger personalization and orientation towards the individual patient

• Clinical decisions made by scientifically trained therapists, supported by statistical algorithms

• Handling the bulk of potential predictors with predictor selection/machine learning methods

• Manage large N datasets with nearest neighbor methods

• Limits: Early implementation, new territory, evaluation in progress
Thank you for your attention!