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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!

What is individually tailored mental health care?

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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.

(The White House – Precision Medicine Initiative. Barack Obama, January 30, 2015)

Precision mental health

Personalized treatment selection

Individually tailored mental health care

What is individually tailored mental health care?

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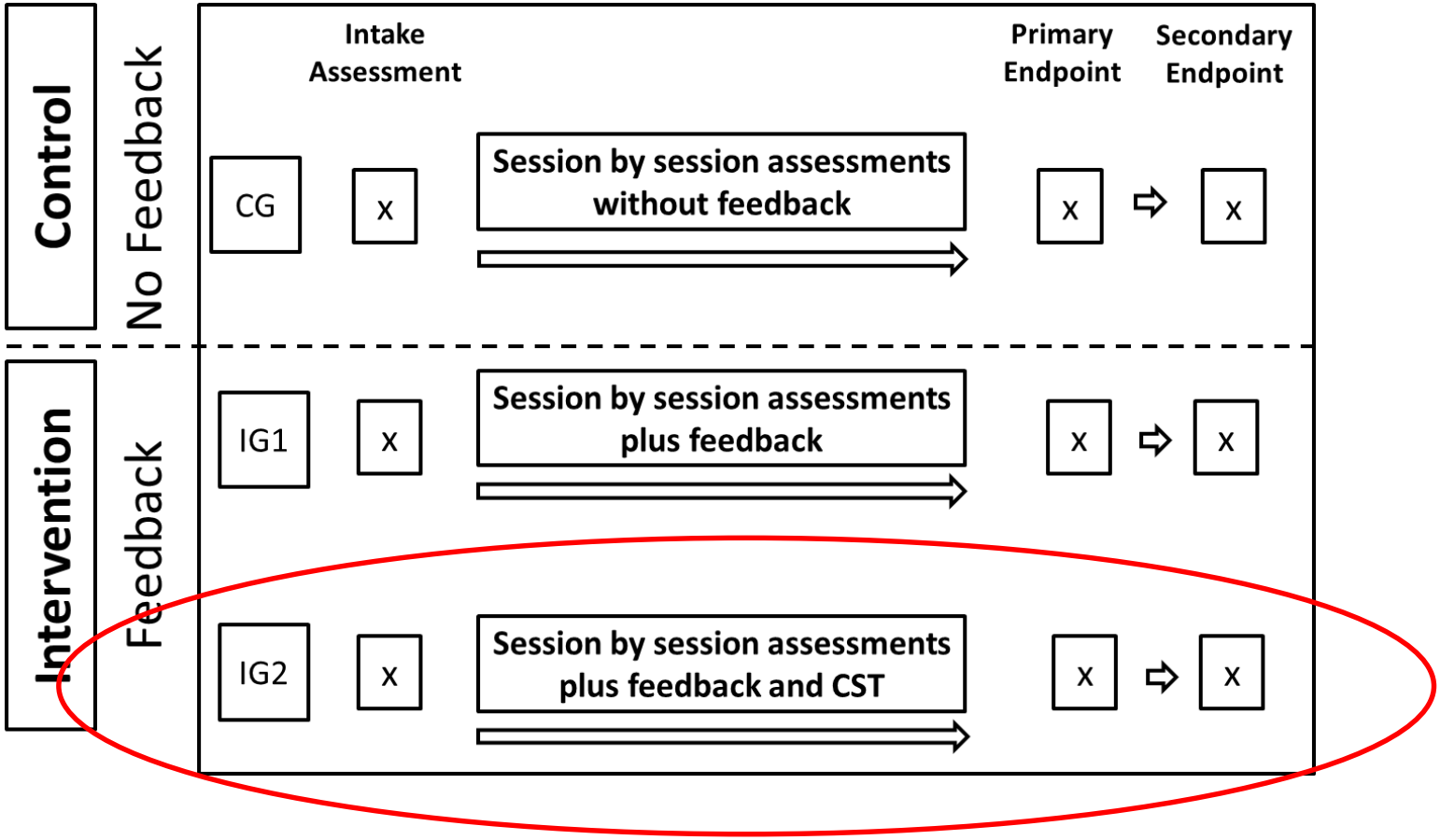
- Robert DeRubeis et al. – University of Pennsylvania, Helena Kramer et al. – Stanford University
- Adam Checkroud et al. – Yale University, Ronald Kessler et al. – Harvard Medical School
- Jamie Delgadillo, Michael Barkham et al. – University of Sheffield, Aaron Fisher et al. – UC Berkeley
- Hanna van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

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Patients

First contact (registration)	Before the 1st session
• 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	**The same questionnaires as after the registration!**

Personalized treatment predictions and adaptive problem solving

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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?

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Feedback system

Session reports | Portal | Room reservation system | Language | Login

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

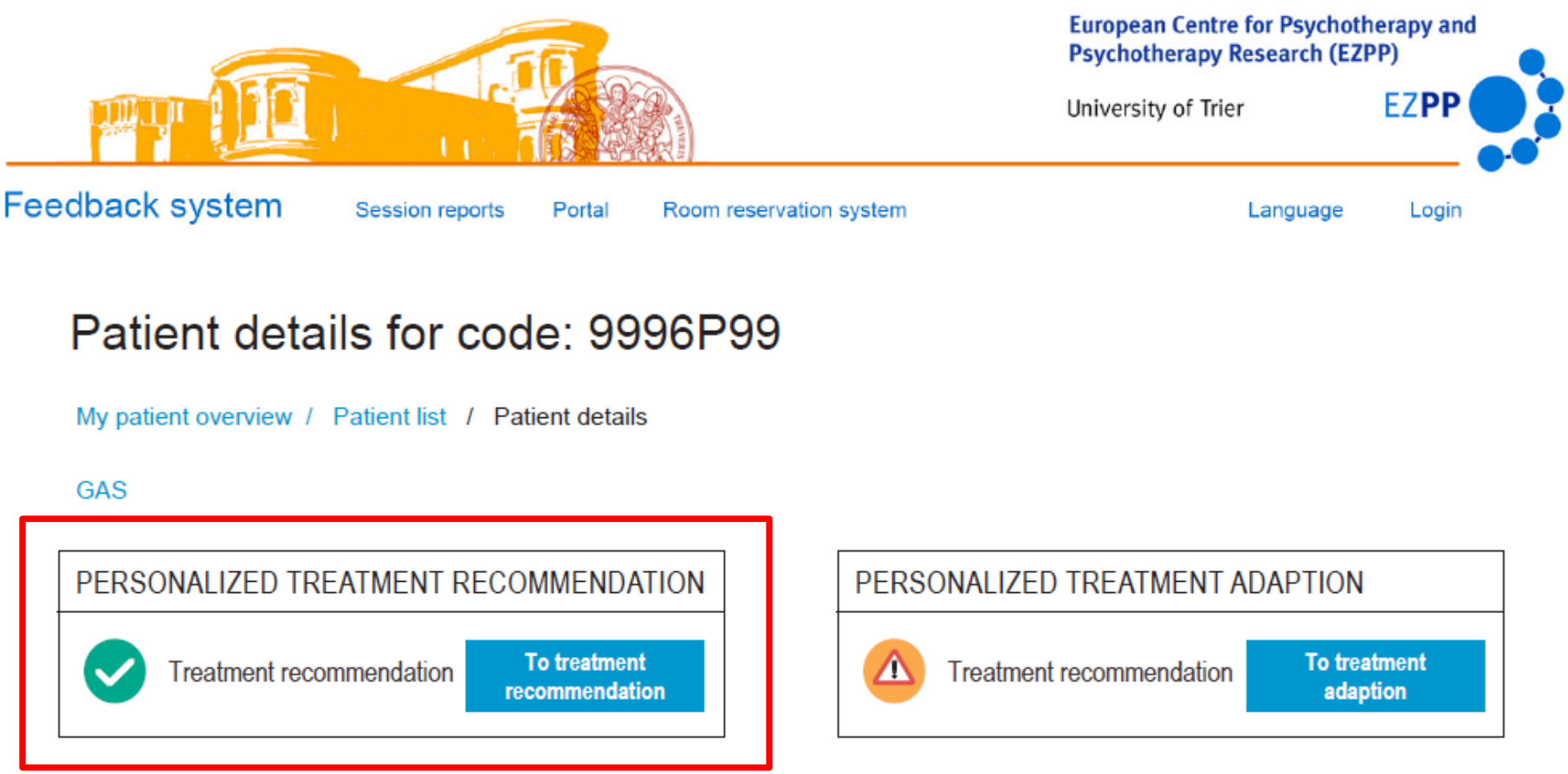
Assessment	Date
Z 10	2014-12-01
Z 05	2014-10-01
PR	2014-08-01
WZ	2014-06-01

PROGRESS REPORT

Last assessment	Z 10
Date	2014-12-01

Progress

Link



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

Therapy Expectation / Drop-Out

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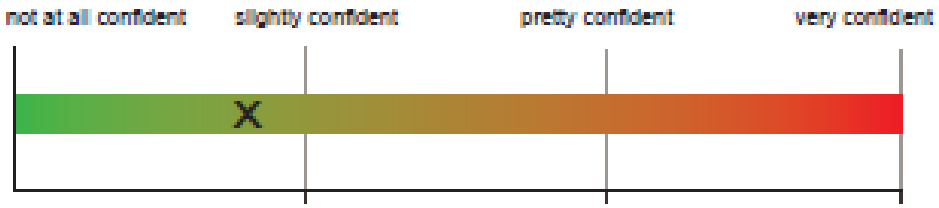
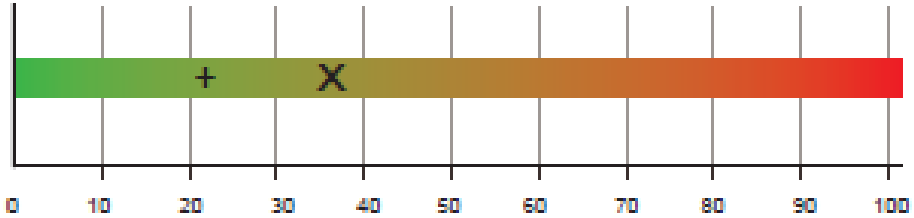
THERAPY EXPECTATION / DROP-OUT

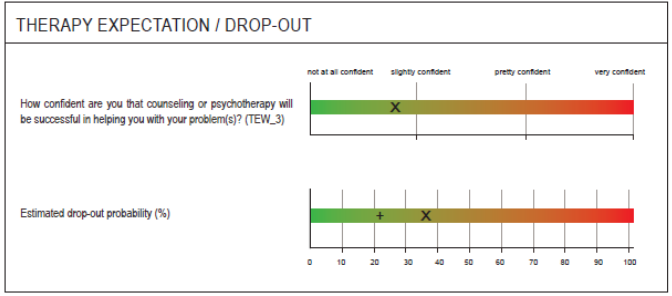
How confident are you that counseling or psychotherapy will be successful in helping you with your problem(s)? (TEW_3)



Estimated drop-out probability (%)



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

Therapy Expectation / Drop-Out

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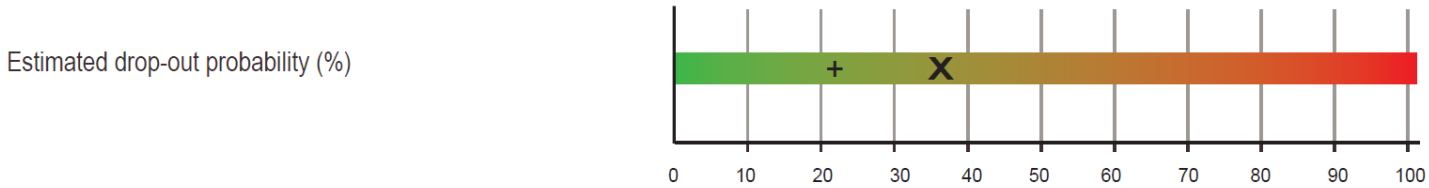
Results (weights) of BRLasso and logistic regression:

	BRLasso (all)	GLM	p-value
FEP-2	-0.230	–0.697	<.01
HSCL	0.261	0.609	<.01
PSSI – Subscale histrionic	0.322	0.359	<.01
OQ-30 – Subscale interpersonal relationships	0.411	0.530	<.001
PSSI – Subscale obsessive-compulsive	-0.416	–0.320	<.01
Therapist's therapy expectation for the patient	-0.509	–0.513	<.001
High school education	-0.586	–0.610	<.001



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Treatment recommendation	To treatment recommendation

PERSONALIZED TREATMENT ADAPTION	
Treatment recommendation	To treatment adaption

1. Therapy Expectation / Drop-Out
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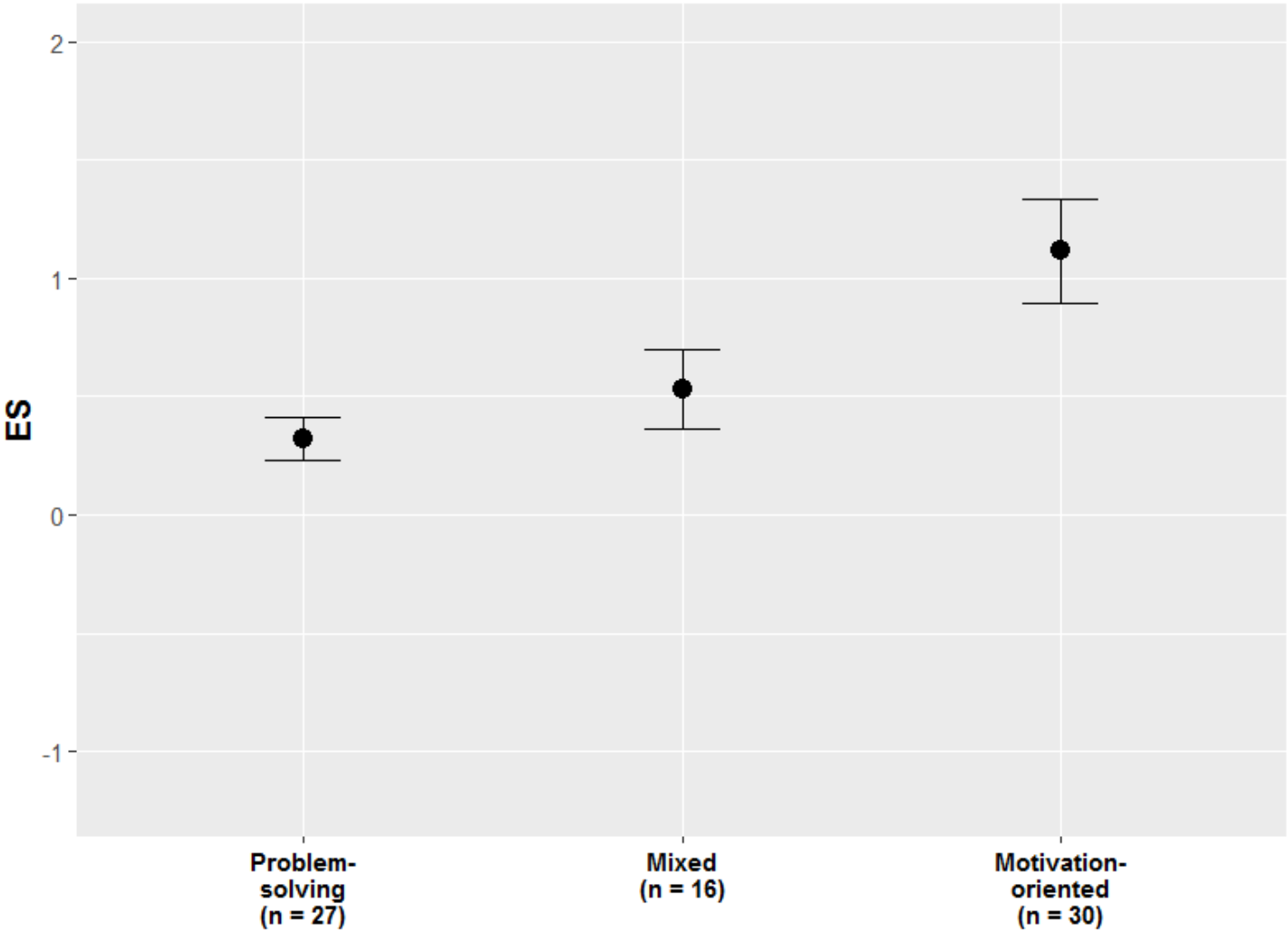
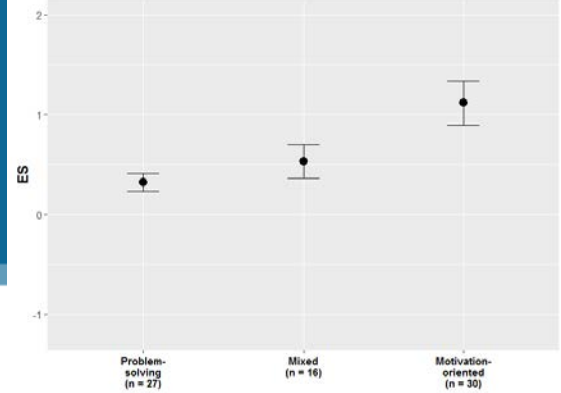
Personalized Treatment Prediction



Personalized Treatment Prediction



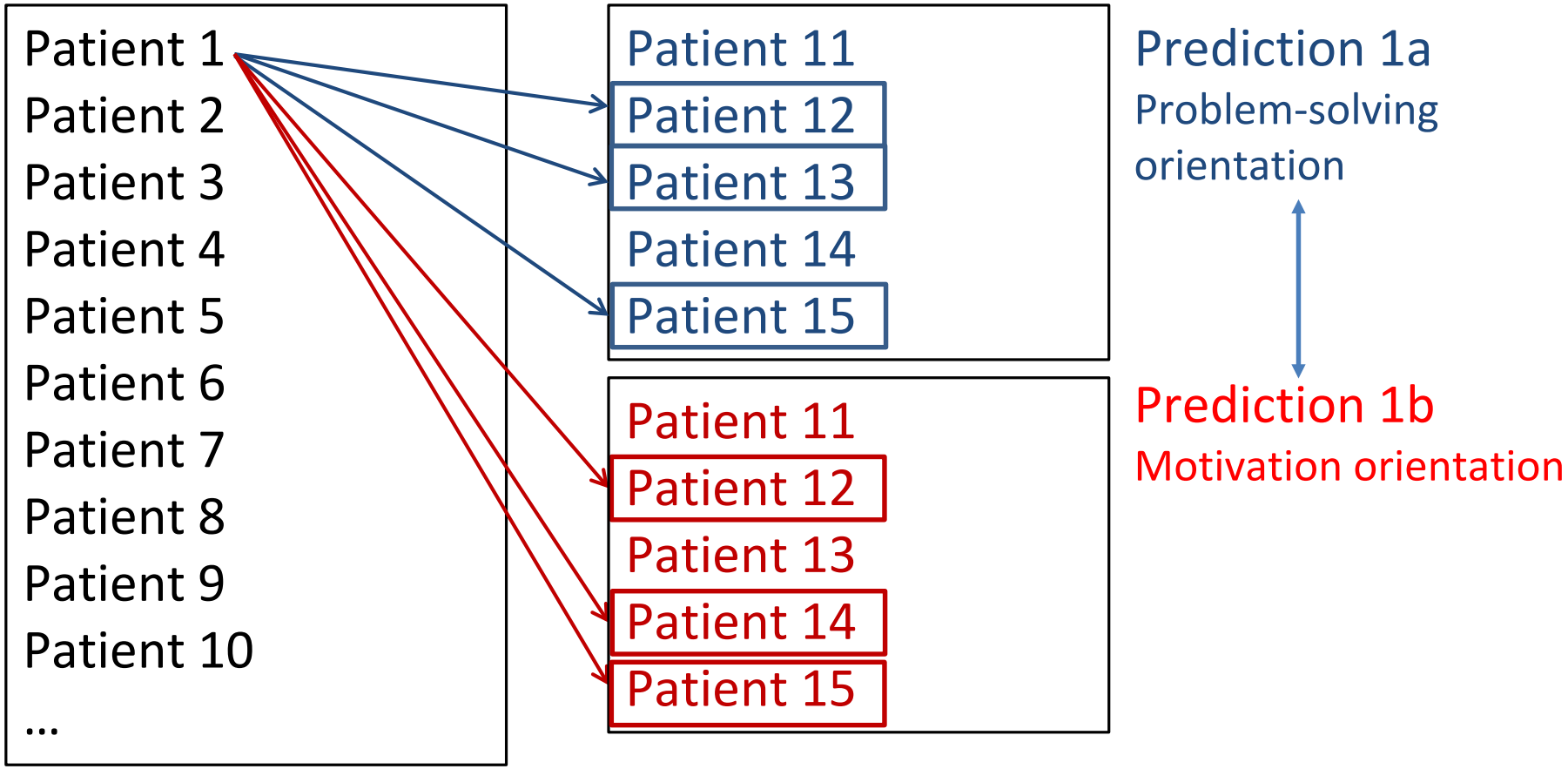
- Total N=1234; Groups: Problem-solving n=509, Mixed n=254, Motivation-oriented n=471
- Problem-solving oriented approach focused on working on concrete problem situations and options for action.
- Relational and motivation-oriented approach focused on establishing the therapeutic alliance, therapy goals 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).

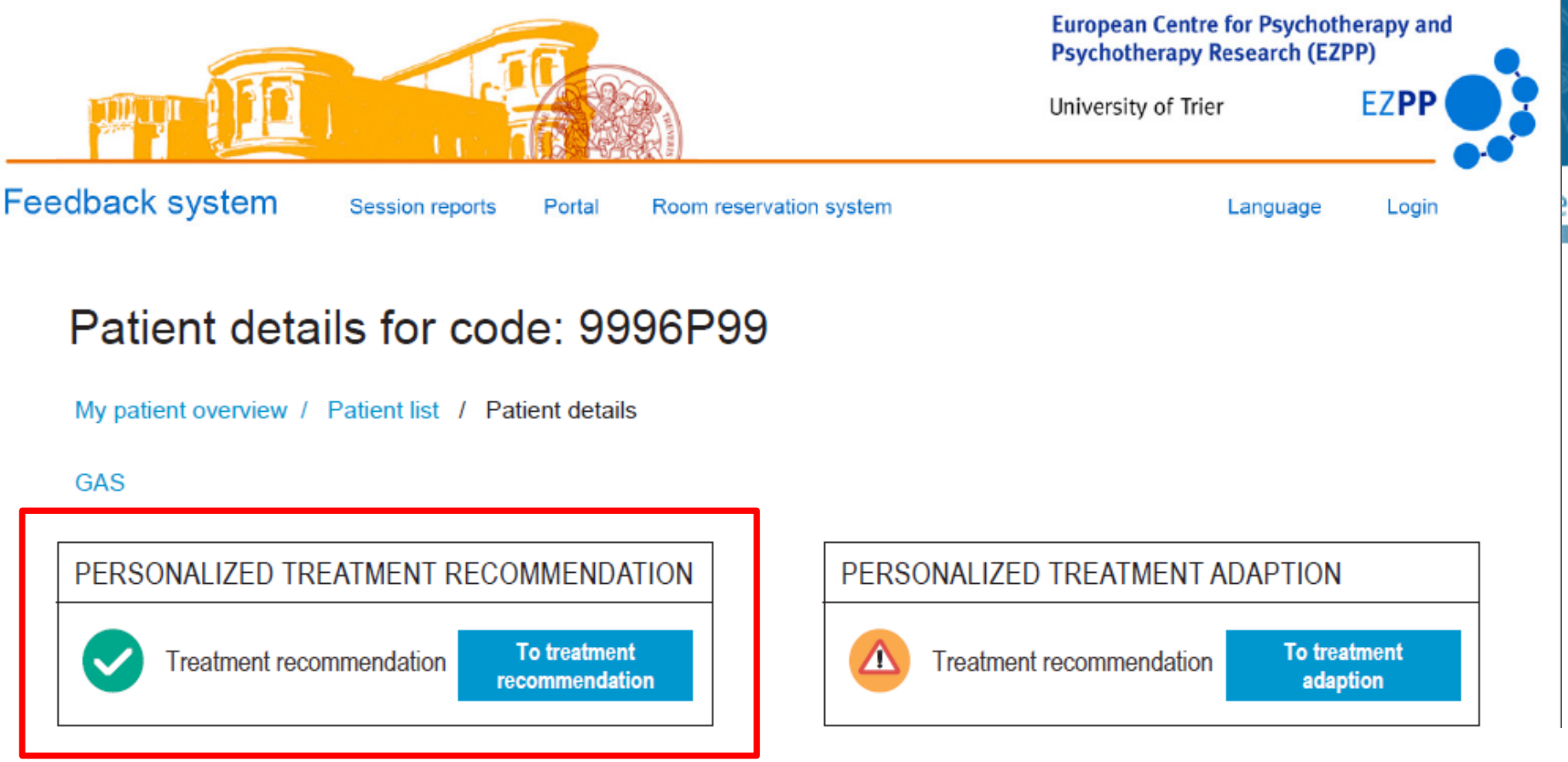
Nearest Neighbor (NN) Approach

- Adapted from avalanche forecasting

- Improve predictions based on large databases by using only comparable cases (Lutz et al., 2005, 2006)

Nearest Neighbor (NN) Approach





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

Nearest neighbor patients for the purpose of supervision and intervision

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- 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.

SIMILAR PATIENT-THERAPIST DYADS

This indicator calls your attention to therapists, who have already treated similar cases, enabling you to contact them for the purpose of intervision. The ten patients who are most similar to your case are displayed. The thicker the line, the more similar the patients. Red lines indicate direct connections between the selected patient-therapist dyad and the comparison patients, while the blue lines indicate the connections between the comparison dyads.

PERSONALIZED TREATMENT RECOMMENDATION

Treatment recommendation

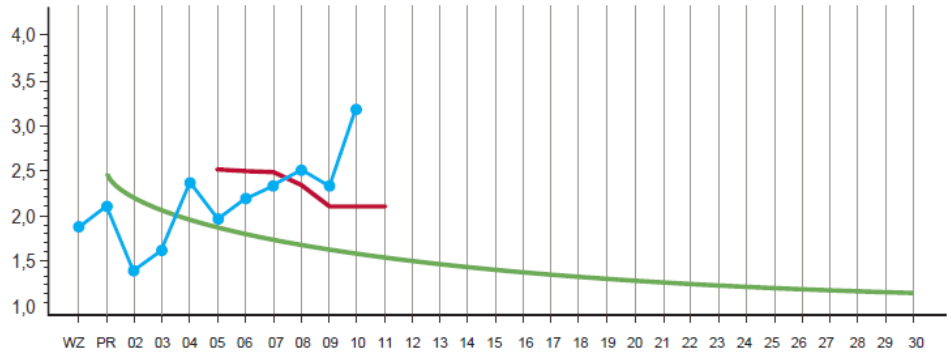
To treatment recommendation

PERSONALIZED TREATMENT ADAPTION

Treatment recommendation

To treatment adaption

GENERAL SYMPTOM PROGRESS (HSCL-11)



GENERAL SYMPTOM PROGRESS

General symptom progress is off track.

CLINICAL SUPPORT TOOLS

Risk/Suicidality

Motivation/Therapy goals

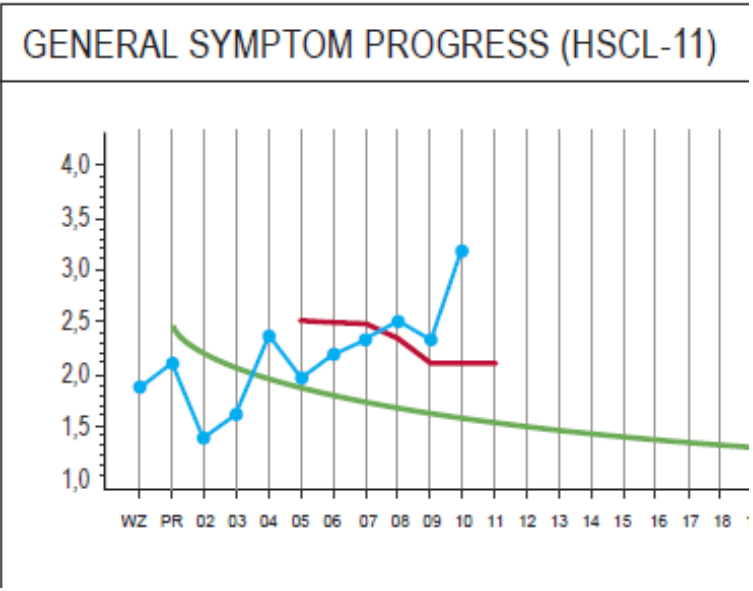
Therapeutic alliance

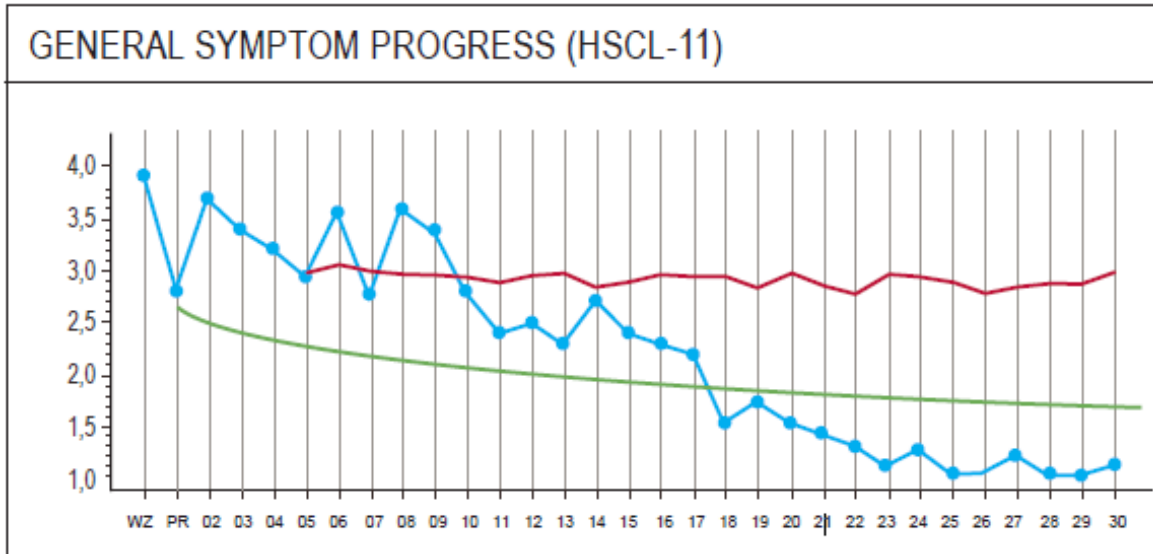
Social support/Critical life events

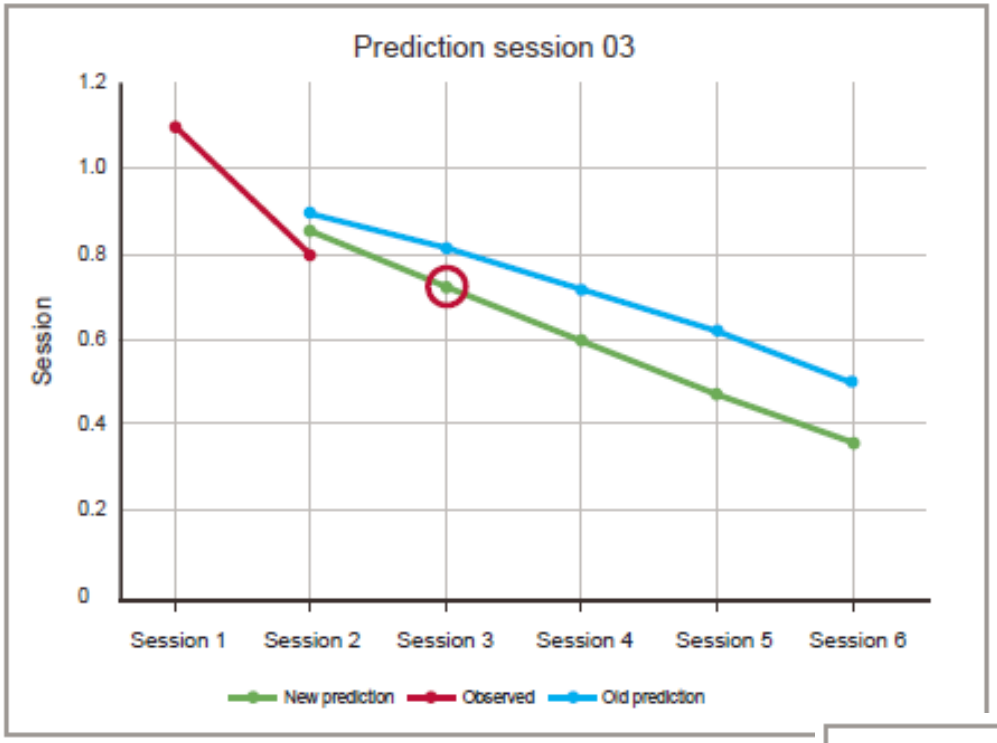
Emotion regulation/Self-regulation

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 ≤ ±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)







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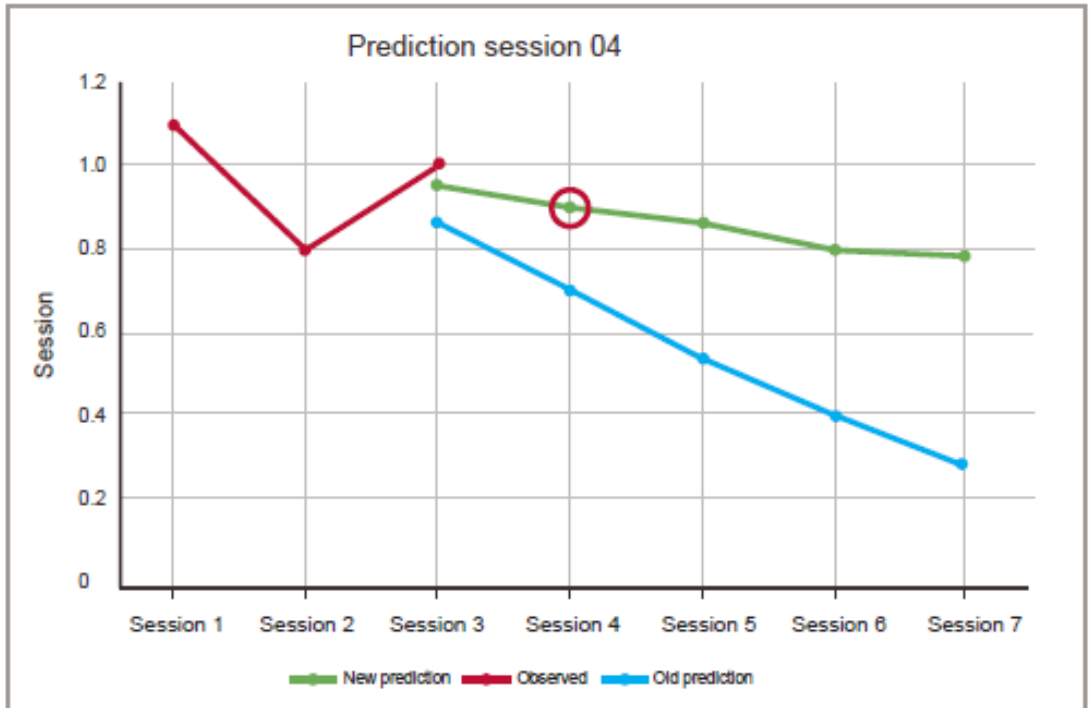
$$OQTot._{tj} = \beta_{0j} + \beta_{1j} Sessions_{tj} + r_{tj}$$
$$\beta_{0j} = \gamma_{00} + \gamma_{01}(\#Sessions_j - AMSess.) + e_{0j}$$
$$\beta_{1j} = \gamma_{10} + \gamma_{11}(\#Sessions_j - AMSess.) + e_{1j}$$

Consideration of treatment duration

Adaptive prediction model - Example



Clinical support tools (CST)

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GENERAL SYMPTOM PROGRESS

General symptom progress is off track.

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

CLINICAL SUPPORT TOOLS

Risk/Suicidality

Motivation/Therapy goals

Therapeutic alliance

Social support/Critical life events

Emotion regulation/Self-regulation

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.

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Therapy motivation Goal development I Goal development II Method development Promotion of re

Therapy motivation is determined using the ASC. Each item is accessible to the therapist.
Cut-off value <= 32

ASC SCALES

Therapy motivation

Questionnaire ASC Items for scale: Motivation

High value – 1: Strongly disagree; 2: Slightly disagree; 3: Neutral; 4: Slightly agree; 5: Strongly agree

Nr.	Question	
23.	I wonder what I am doing in therapy; actually I find it boring	4
24.	Honestly, I really don't understand what I can get from therapy.	5
25.	I am not really sure what to work on in therapy.	4
26.	I had thoughts about quitting therapy; it's just not for me.	5
27.	I don't think therapy will help me feel any better.	5
28.	I have no desire to work out my problems.	4
29.	Although I am currently unhappy with life, there is nothing I can do about it now.	4
20.	Through therapy I am taking more responsibility for changing my life.	2
31.	I am in therapy because someone is requiring it of me.	5

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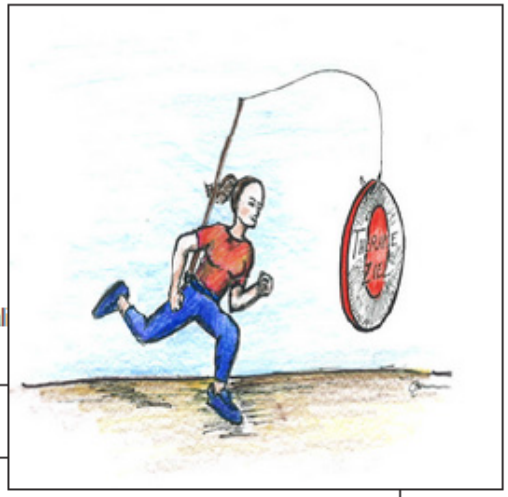

ASC SCALES

Therapy motivation

Low patient motivation increases the risk of a less successful therapy and is often associated w
therapeutic process. In therapy, it is therefore necessary to react to the resistant displayed by t
motivation. For example, the patient himself may not be suffering, the disorder could have adv
fundamental problem should therefore be explored. Depending on the cause of the lack of pati
described in more detail in the following. The therapist's fundamental attitude, however, should

Positive regard

Empathic, accepting of the patient as a person (not necessarily of content)

Informative and explanatory

Confident, even in states of uncertainty

Equal and not dominant

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

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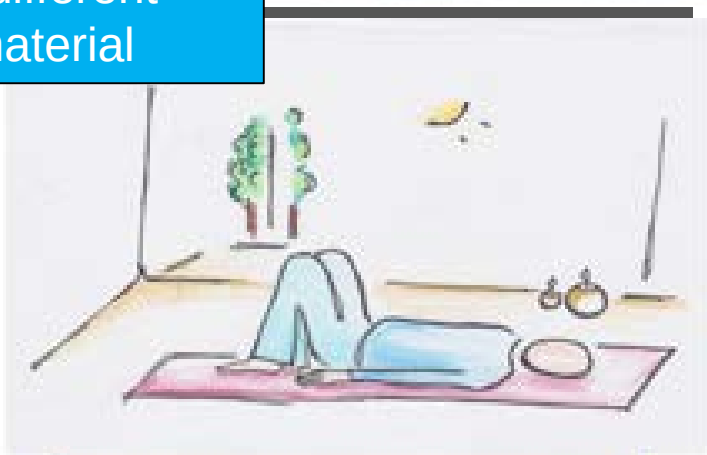
Kosten-Nutzen Analyse: Veränderung - ja oder nein?

	Änderung des bisherigen Zustands	Beibehaltung des bisherigen Zustands
Vorteile		
Nachteile		

Therapists are able to download different therapy material



Outlook

Data

- **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

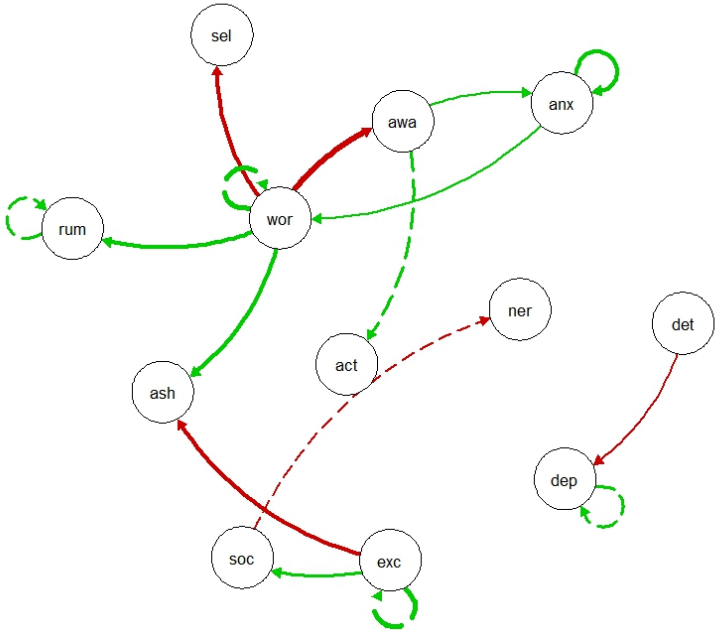
Improving dropout prediction

- Network analysis based on ecological momentary assessments

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

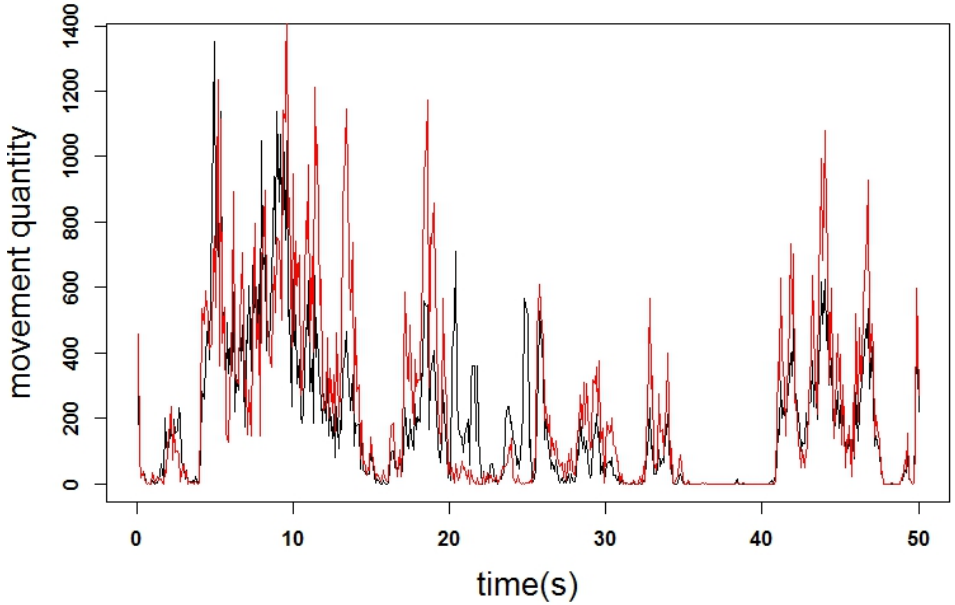
$$\gamma_{kpd} = \beta_k + b_{kp}$$

- 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

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- Stronger personalization and orientation towards the individual patient
- Clinical desicions 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!

☺

Schwartz, B., & Lutz, W. (2018, June). Personalized predictions and clinical support tools based on big data: Development and implementation. Paper to be presented at the Big Data in Psychology Conference 2018, Trier, GER.