Data driven digital mental health promotion & disease prevention

26. Österreichische Gesundheitsförderungs-konferenz des Fonds Gesundes Österreich

Villach, 12 June 2024

Prof. dr. Heleen Riper
Vrije Universiteit, Amsterdam


EAT TOGETHER
Foodsharing Volksküche
Essen für ALLE
WIR KOCHEN MIT GERETTETEN LEBENSMITTELN
machen wir die Welt Lebenswerter
Kein Mittagsmenü mehr verpassen?
RADFESTIVAL AM WÖRTHERSEE

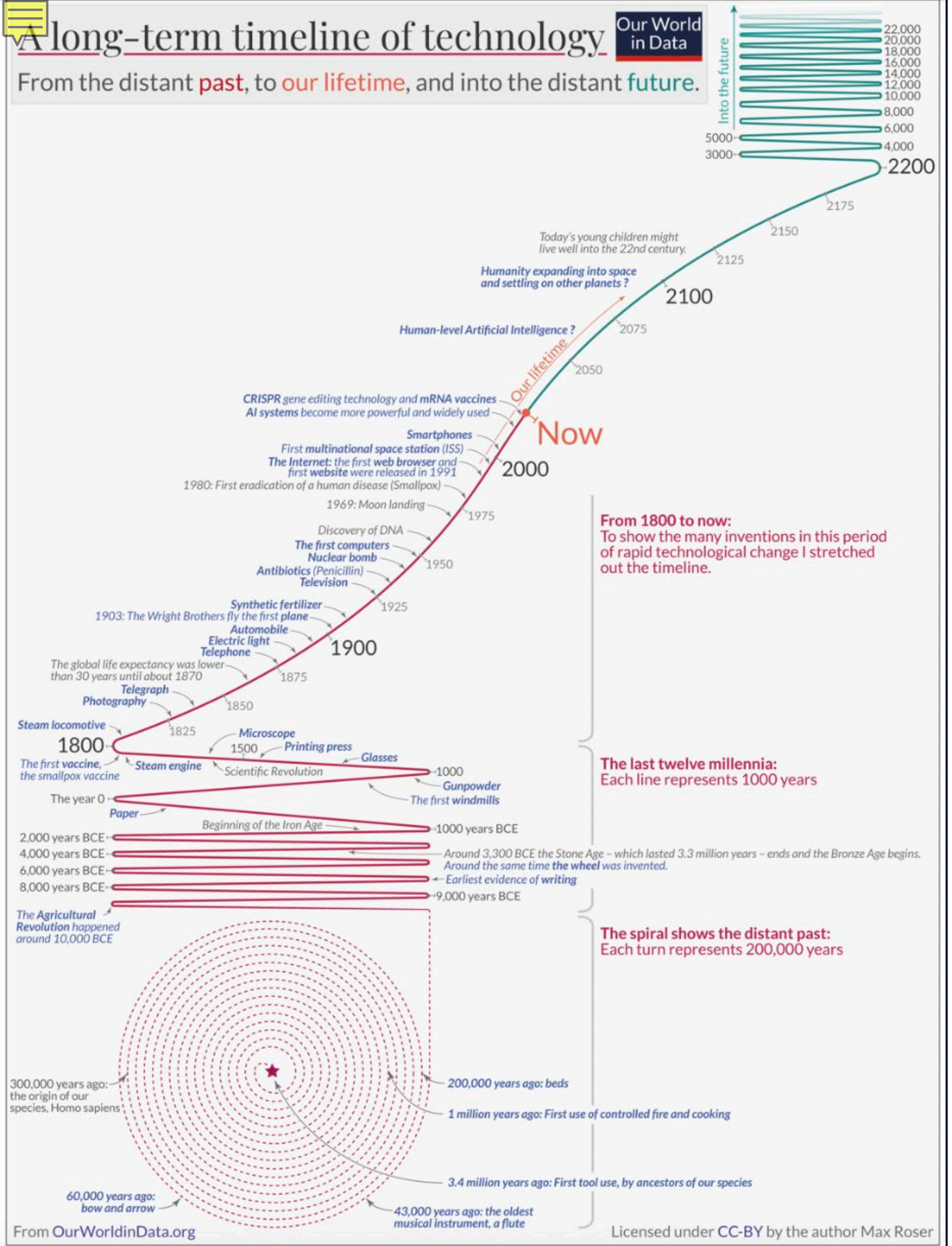
How familiar are you with digital interventions?

Unguided
(asynchronous)

Guided
(asynchronous)

Blended (asynchronous
and synchronic)

Videoconferencing
(synchronic home or clinic)



Technology changes extraordinarily fast

For the good and the bad

Human-Level AI?

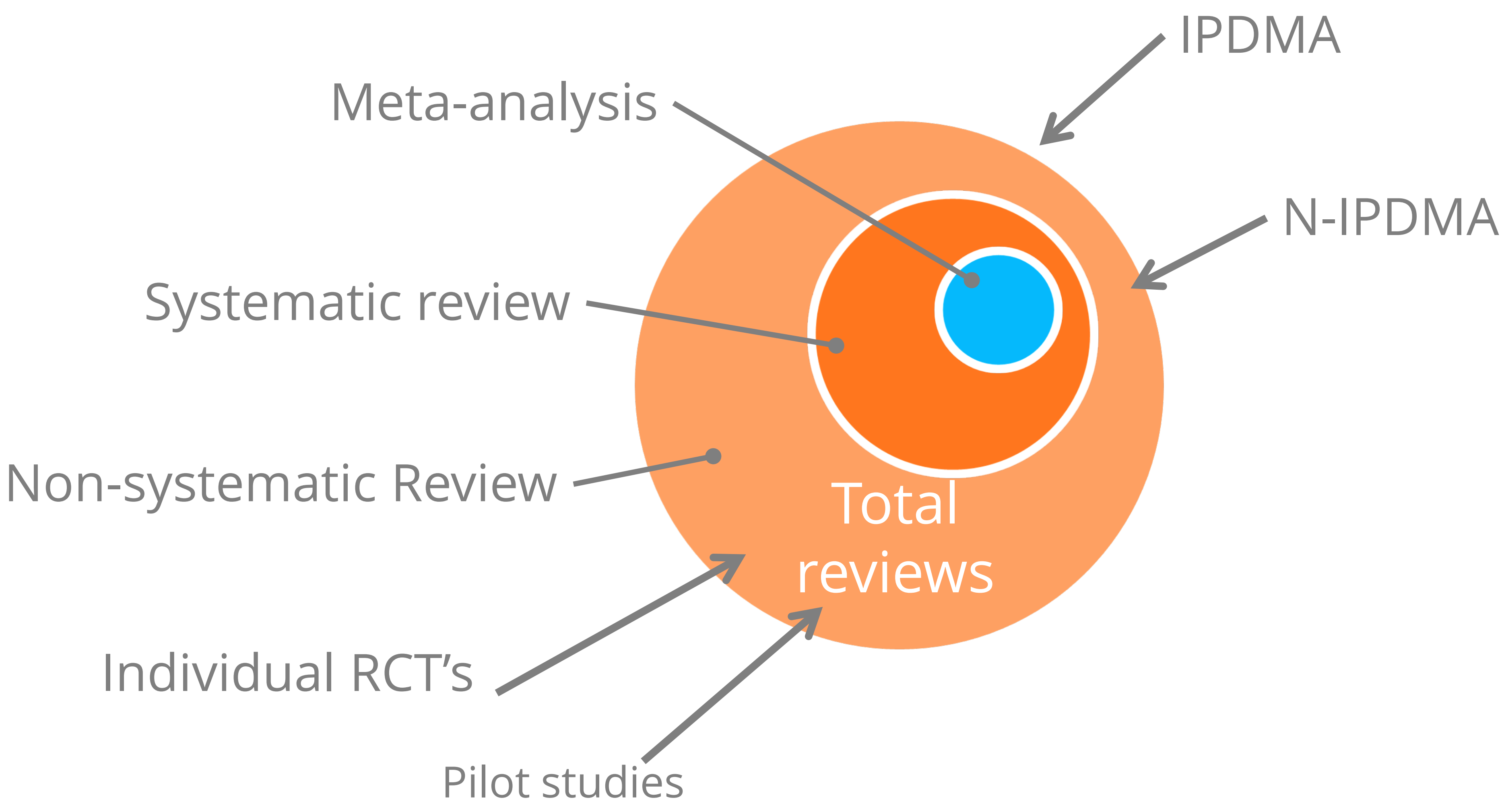
Max Roser, 2023

Start 3,4 million years ago

Why data driven digital mental health promotion & disease prevention?

- To create and implement evidence based digital mental health promotion interventions
- Randomized controlled trials and meta-analytics : golden standard
- Realworld data & realworld evidence

Levels of Evidence



25 years Digital Mental & Behavioural Health

2022 Pittsburgh — **AI & Just In Time Adaptive Interventions**

2019 Auckland — AI & ML & Sensoring, **digital phenotyping**

2017 Berlin — **Mobile health** & EMA

2016 Seattle — **Youth**

2014 Valencia — **Serious Gaming**

2013 Chicago — **Micro interventions**, Individual Patient Data Meta-Analysis

2011 Sydney — **Beyond CBT**, meta-analyses

2009 Amsterdam — Globalization & Digital **Ecological Momentary Assessment**

2007 Charlottesville — **Cost-effectiveness** studies and implementation

2006 Stockholm — ISRII: Assessing **clinical effective**ness (RCT)

2000 - 2004 — **Development** of internet-based interventions

Wright et al. ***(2023)*** *Interventions with Digital Tools* ***for Mental Health Promotion among 11–18 Year Olds: A Systematic Review and Meta-Analysis****.* ***(Anxiety)***

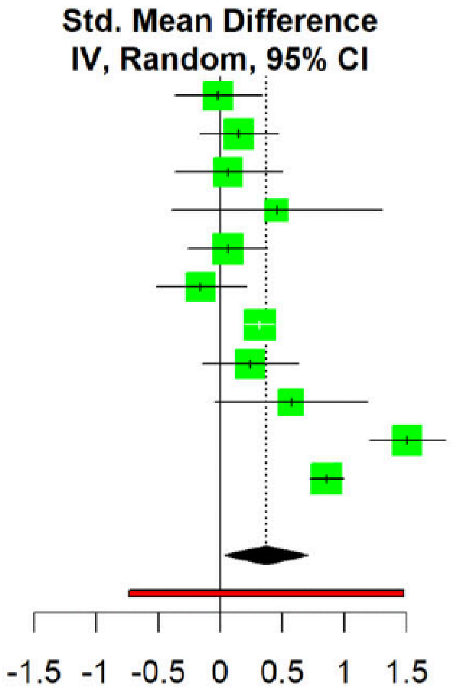
Small sign. Effects Anxiety, well-being, protective factors

- **School & support**
- **High = more**

N = 27 studies (13,216 participants): mental health literacy, well-being, (help-seeking behavior, stress management, relaxation, mindfulness, resilience and positive psychology.

	Experimental			Control					
Study	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**SMD**	**95% CI**
Calear et al., 2016	4.65	4.12	79	4.56	4.96	52	9.4%	-0.02	[-0.37; 0.33]
Egan et al., 2021	1.85	0.95	73	1.99	0.90	81	9.6%	0.15	[-0.17; 0.47]
Kauer et al., 2012	9.80	9.30	50	10.40	9.60	35	8.8%	0.06	[-0.37; 0.50]
Malboeuf-Hurtubise et al., 2021	2.87	0.83	11	3.50	1.70	11	5.8%	0.45	[-0.40; 1.30]
Manicavasagar et al., 2014	6.38	7.26	62	6.86	8.61	92	9.6%	0.06	[-0.26; 0.38]
O'Dea et al., 2020	9.78	4.20	55	9.12	4.15	60	9.3%	-0.16	[-0.52; 0.21]
O'Dea et al., 2021	4.21	4.78	400	5.82	5.33	878	10.6%	0.31	[0.19; 0.43]
Osborn et al., 2020	7.92	4.48	50	9.00	4.45	53	9.1%	0.24	[-0.15; 0.63]
Perkins et al., 2021	10.99	5.61	21	14.58	6.70	21	7.4%	0.57	[-0.05; 1.19]
Schleider et al., 2020	18.83	0.75	106	19.95	0.73	105	9.7%	1.51	[1.20; 1.81]
Zheng et al., 2021	3.49	0.33	467	3.79	0.37	429	10.6%	0.86	[0.72; 0.99]
Total (95% CI)			**1374**			**1817**	**100.0%**	**0.37**	**[0.04; 0.70]**
Prediction interval									**[-0.73; 1.47]**

Heterogeneity: $Tau^2 = 0.2151$; $Chi^2 = 115.34$, $df = 10$ ($P < 0.01$); $I^2 = 91\%$

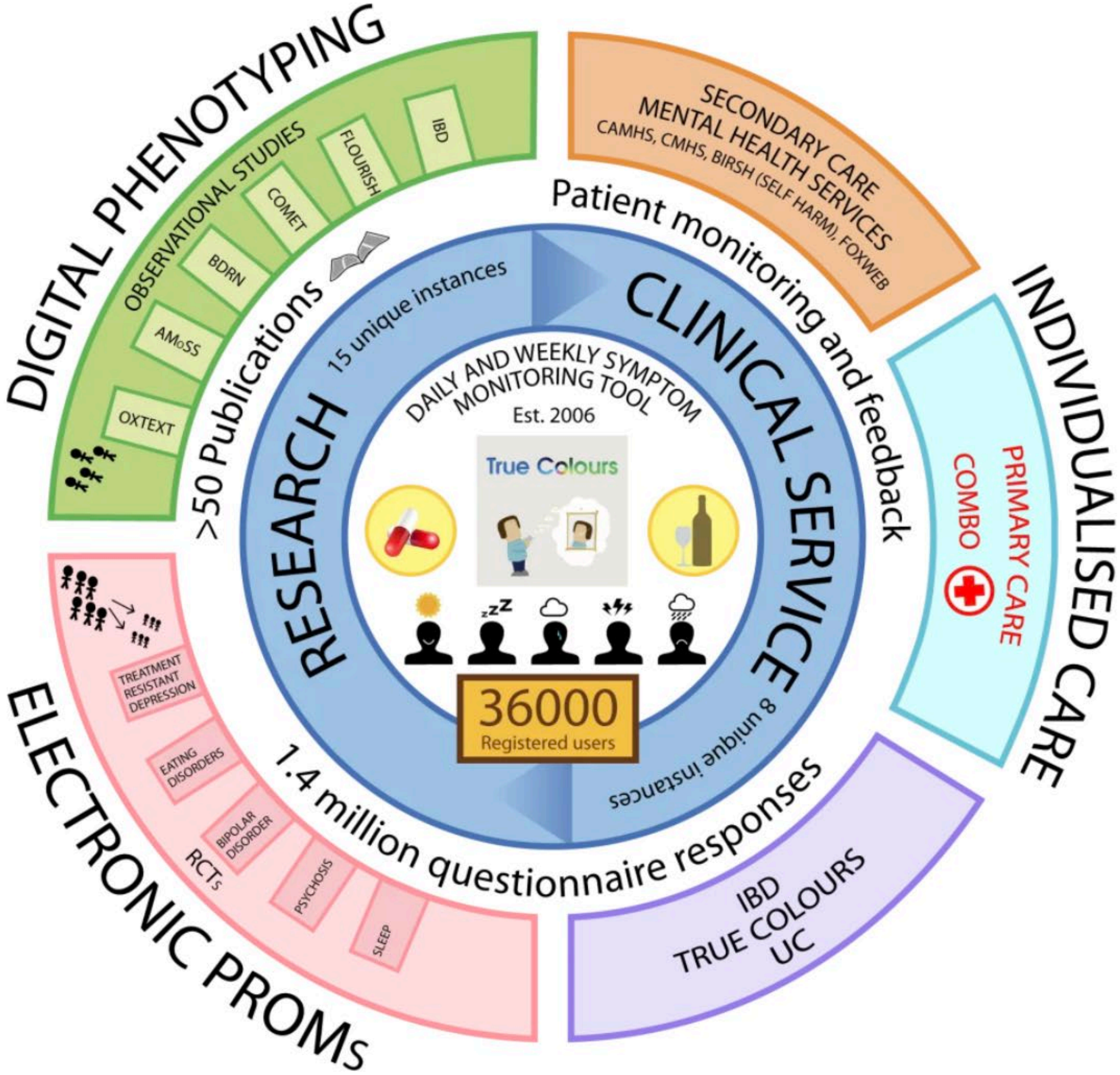


Difference between digital mental health promotion & universal & selected prevention not always clear cut

Twenty-five years of digital mental health:

From platform development, feasibility and assessment of effective mental health promotion towards

User-centred, Personalized Prediction models for Monitoring and Prevention and Treatment supported by (generative) AI & JITAIs



TRUE COLOURS?

Dr. Ropin?

2009 start

Goodday et al. (2020) The True Colours Remote Symptom Monitoring System: A Decade of Evolution. JMIR

EMA

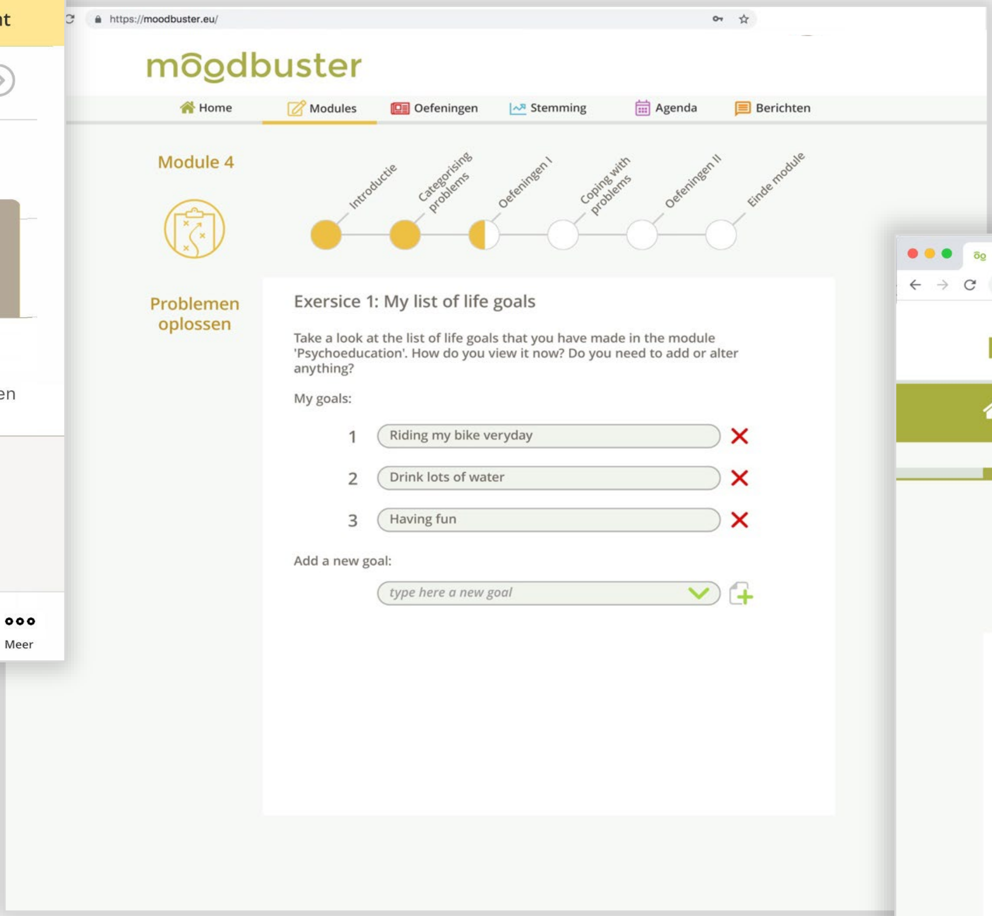
- Mood and behaviours change over **time**
- **Context** of mood and behaviour manifestations is important
- Large differences between people (**heterogeneity**)
- Retrospective assessment
  - Recall bias
  - Over generalization
  - Peak end rule

Patient Health Questionnaire-9 (PHQ-9)

Over the last 2 weeks, how often have you been bothered by any of the following problems?	Not at all	Several days	More than half the days	Nearly every day
• Little interest or pleasure in doing things	0	1	2	3
• Feeling down, depressed, or hopeless	0	1	2	3
• Trouble falling or staying asleep, or sleeping too much	0	1	2	3
• Feeling tired or having little energy	0	1	2	3
• Poor appetite or overeating	0	1	2	3

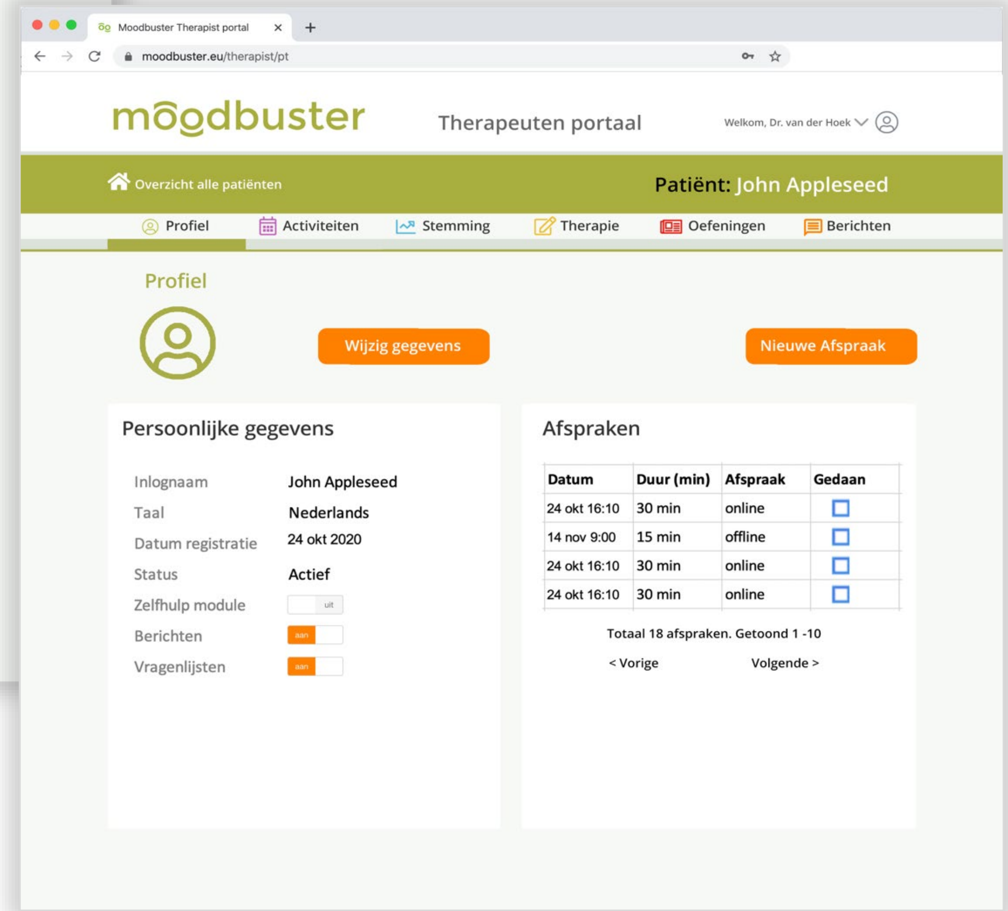
MoodBuster 2.0

Mobile App



Patients' Portal

Content Management System



Therapists' Portal

VU University, Amsterdam &
INESC TEC, Porto & UL, Limerick

Digital Phenotyping

"The moment-by-moment quantification of the individual-level human phenotype in situ using passive and/or active data from personal digital devices, in particular smartphones and sensors."

"**It** also makes use of wearable sensors that capture real-time physiological data, social media fora or interactions with others captured via call and text logs."

"**Data obtained** may be viewed as a proxies for under-lying states of behavior, emotion, cognition and environment."

Change of the way how we understand mental health and addictive disorders which are correlated with new means of live data collection

(Onnela 2015, Jain 2015, Torous 2018)

AIMS

- to obtain "objective" markers in addition to self-report, interviews, physical exams, biological markers and brain imaging data
- Examples physiology (heart rate); cognition (e.g. screen use), behavioural (e.g., global positioning system) and social (e.g., call frequency)
- *to increase insights into the temporal dynamics of* our health and behaviour
- predict and prevent onset or relapse

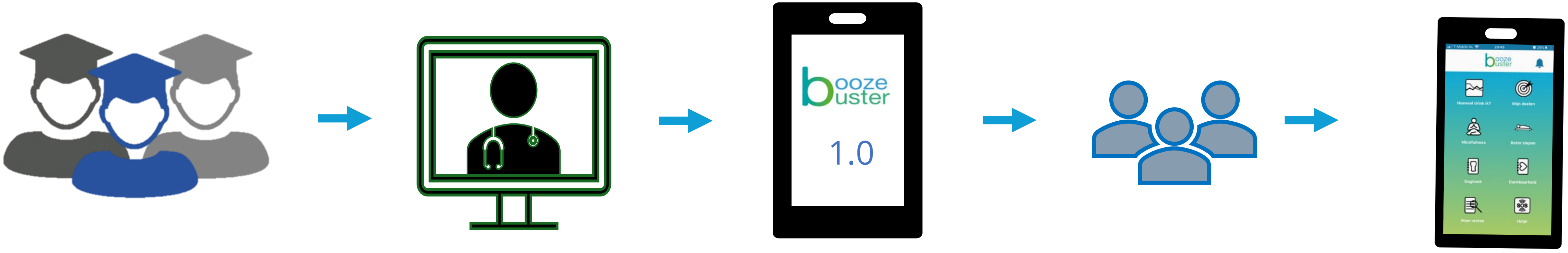
examples

  - to classify mood states on the basis of activity patterns (Mohr et al. 2011)
  - quantification of realworld social networks through Bluetooth signals
  - keyboard touch & speed (Insell 2018)

Boozebuster Smartphone Intervention
to Reduce Young Adults' Alcohol Consumption
Indirect Recruitment & Intervention

Development

Schulte, Boumparis …. Riper (2022). Frontiers in Digital Health



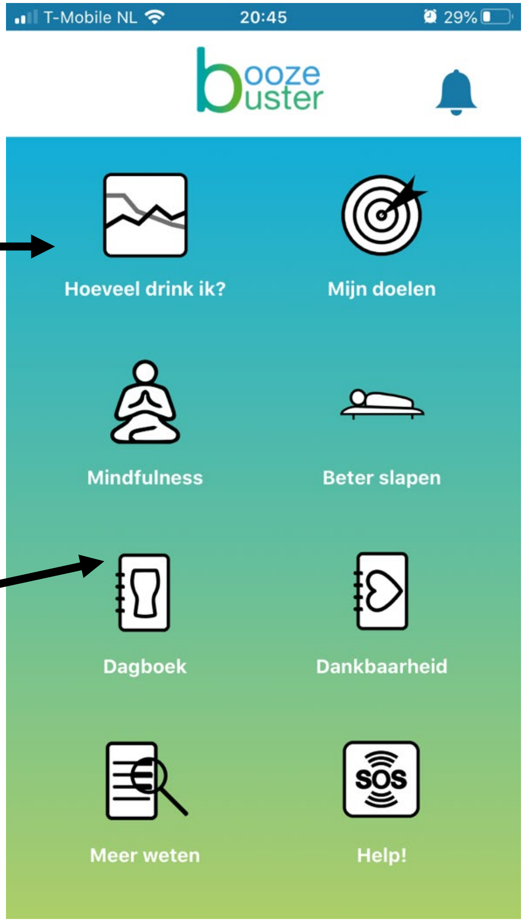
Needs & desirability

Conceptual framework

Prototype evaluation

Technical pilot

Health Promotion Approach
Boozebuster **N =503**



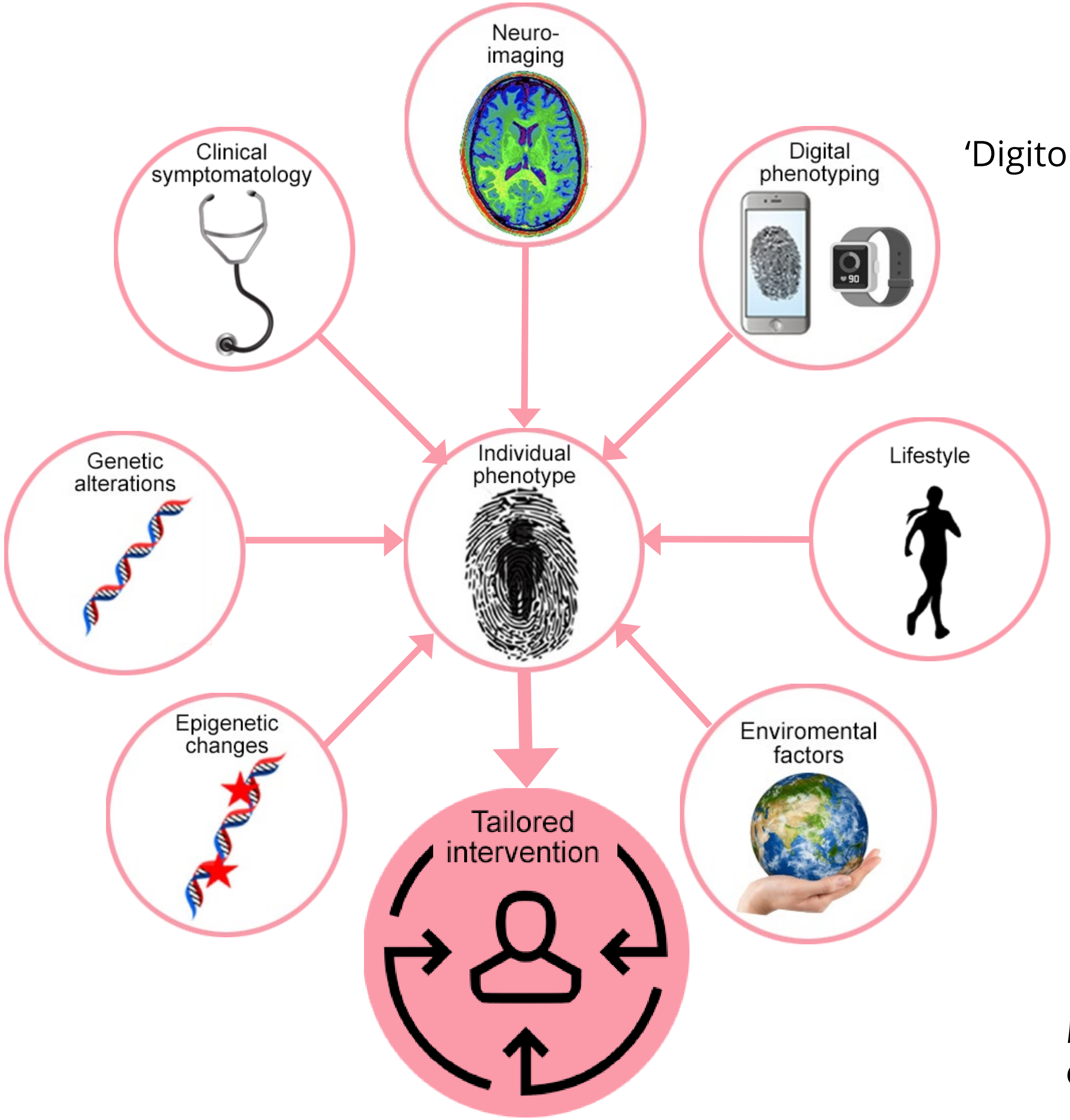
EMA

Results independent of analyses

- Exp v minimal active
- Both groups decreased AC/ NS
- ITT vs. Per protocol vs. Study completers
- Binge drinkers vs. problem drinkers
- RCQ: moderator

DATA Driven

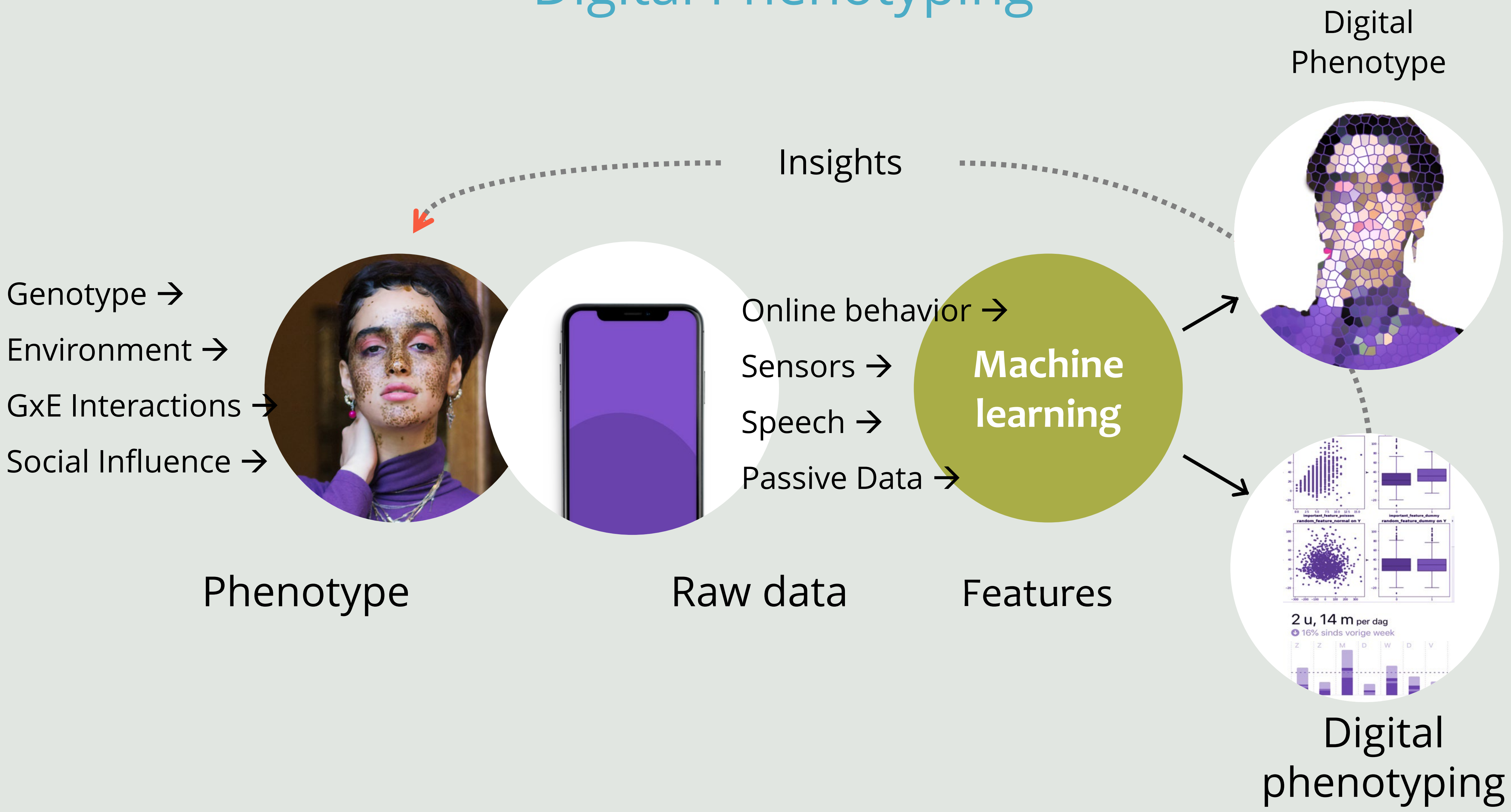
Personalised therapy



'Digitomics'

Based on Barrigon et al. Curr Psychiatry Rep (2019)

Digital Phenotyping



Example: Combined Active and Passive EMA

Internet Interventions 12 (2018) 105–110

Contents lists available at ScienceDirect

Internet Interventions

journal homepage: www.elsevier.com/locate/invent

ELSEVIER

Predicting short term mood developments among depressed patients using adherence and ecological momentary assessment data

Adam Mikus[a], Mark Hoogendoorn[a,*], Artur Rocha[b], Joao Gama[c], Jeroen Ruwaard[d], Heleen Riper[d]

- E-COMPARED DATA
- 5 EU countries
- N = 143 patients
- 9 -425 days of EMA data.

Active & passive EMA

5 countries

2018

Description of the pre-processed input features.

Input feature	Description
Base features	
EMA mood ratings	Averages of the patients daily mood ratings
Additional mood ratings	Indicates whether patient rated mood more than two times (more than the protocol requires) per day
Nationality	The country of origin of the patient
Module completions	Whether a therapeutic module has been completed
Treatment state	The current treatment state of the patient: can be active (before finishing the final module), done (after having finished the final module but still able to access the system) and archived (no longer having access to the system)
Day of the week	Current day of the week
Number of answered questions per day	Number of questions the patient rated a day
Extended features	
EMA ratings	Averages of patients daily EMA ratings (except mood)
Number of treatment days	Total number of days in the treatment
Number of exchanged messages with therapist	The number of messages that have been sent by the therapist
Number of exchanged characters with therapist	The number of characters contained in the messages exchanged with the therapist
Number of messages	Number of feedback messages generated by the MoodBuster application (motivational messages and reminders)
Number of patient messages	Number of messages sent by the patient
Number of web sessions	Number of web sessions
Number of pages in module	The number of pages viewed in the modules
Mood Response time	The response time to an EMA request to rate the mood
Module duration	Duration of the current module since the patient started

Results

a.

AI perspective

Best of 3 prediction models

b.

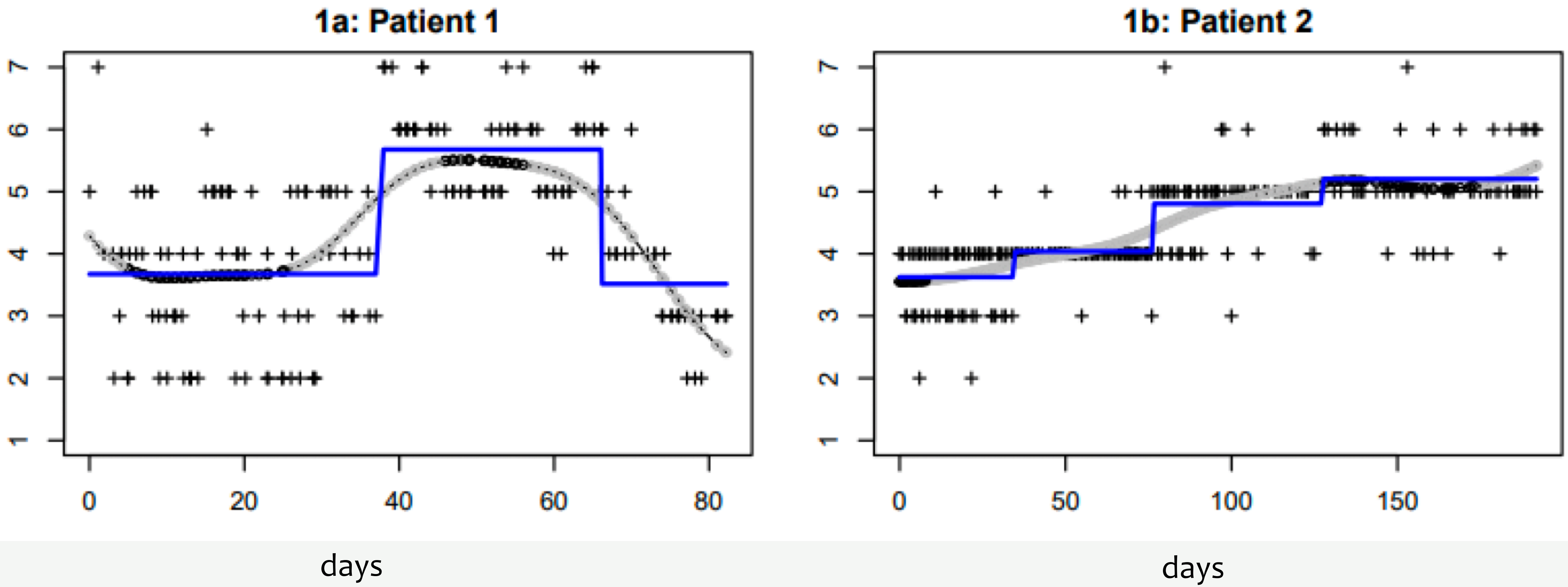
- **Active past EMA mood most influential (A)**
- **adherence & usage data did not improve prediction accuracy (P)**

Results of best predictive models (note: mood has been scaled between 0 and 1, and the RMSE should also be interpreted on that scale).

Set-up	Best model	RMSE result (standard deviation)
Regular input		
Single	GRU 2 layer/GRUP	0.070 (0.00)
Clustered	GRUP	0.066 (0.023)
Individual	LSTMP	0.086 (0.047)
Extended input		
Single	LSTM 1 layer/ LSTMP	0.070 (0.00)
Clustered	GRUP	0.075 (0.026)

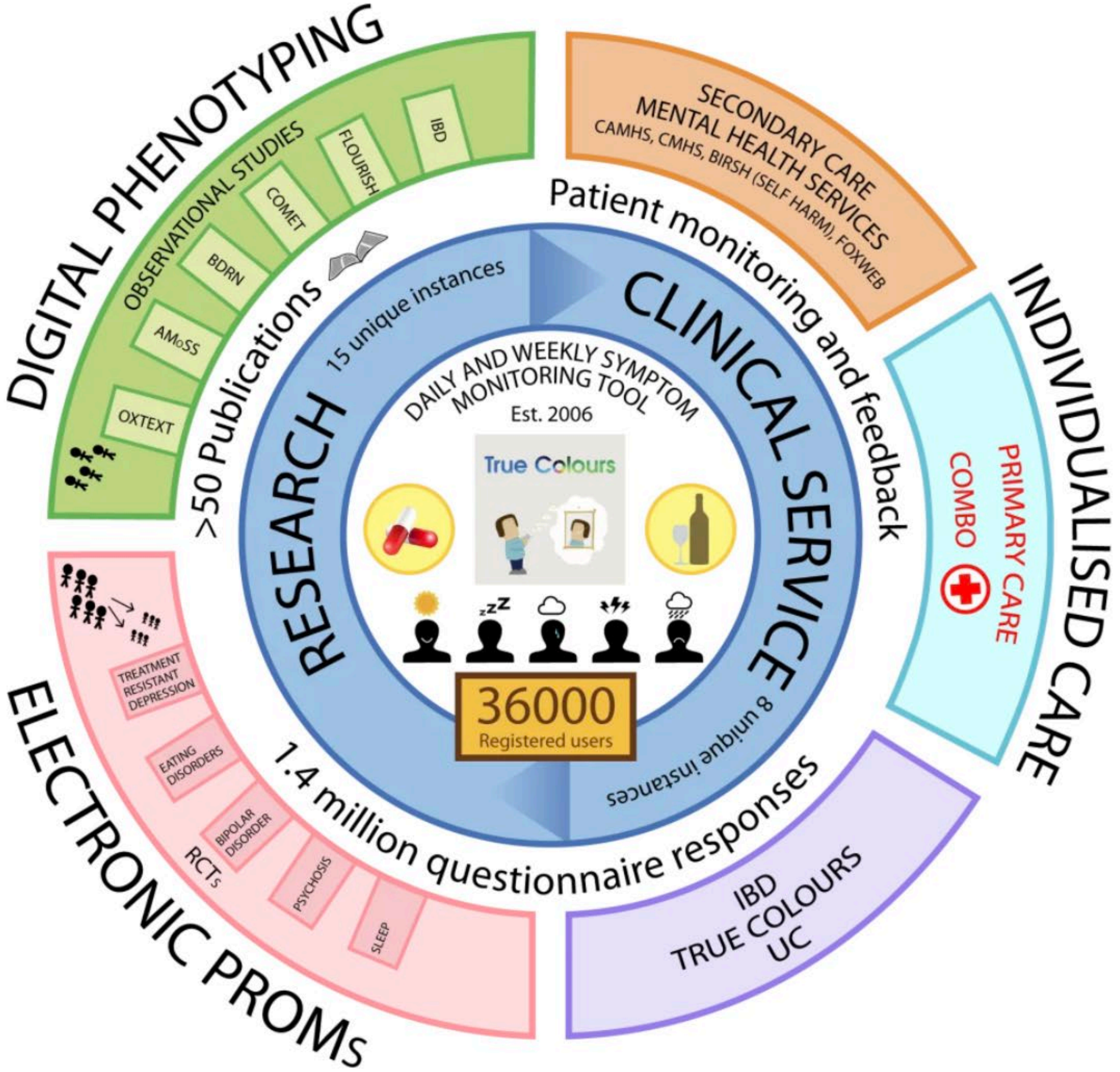
'I have the desire to end my life' 1-7

Figure 1.
Plot of SI EMA data for each participant with estimated long-term trends.



- 3 times a day SI
- sudden & gradual changes

Nuij, C., … Riper (2023). *Proof of Concept Study on Individual Trends in Suicidal Ideation: An Ecological Momentary Assessment Study of 5 Patients Over Three Months . Journal for Person-Oriented Research*



TRUE COLOURS

BD & BPD

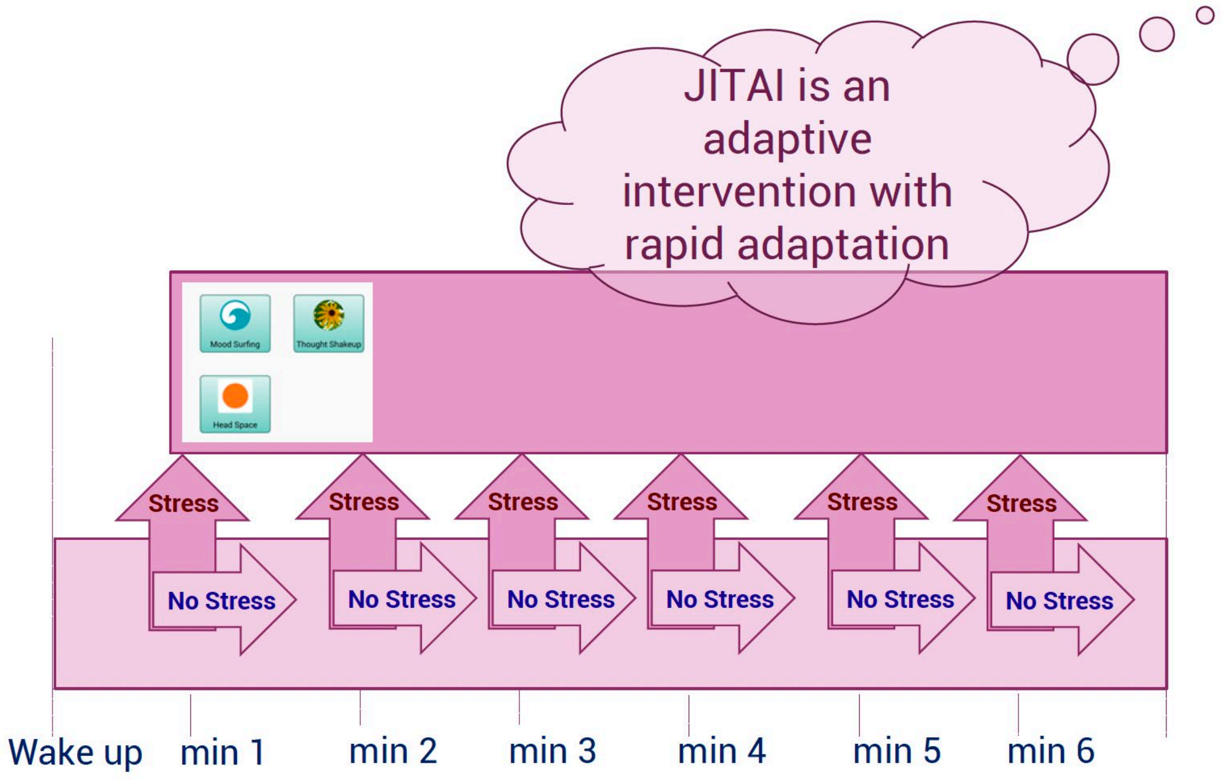
Goodday et al. (2020) The True Colours Remote Symptom Monitoring System: A Decade of Evolution. JMIR

Mental Health Promotion Data-driven Interventions
New directions

Just-In-Time Adaptive Interventions are smartphone interventions: deliver timely tailored support by adjusting to changes in both internal states and external contexts.
No Waste!

MD2K Center of Excellence for Mobile Sensor Data-to-Knowledge

Sense2 STOP



What happens in a day?
smoking cessation

Mental Health Promotion Data-driven Interventions
New directions

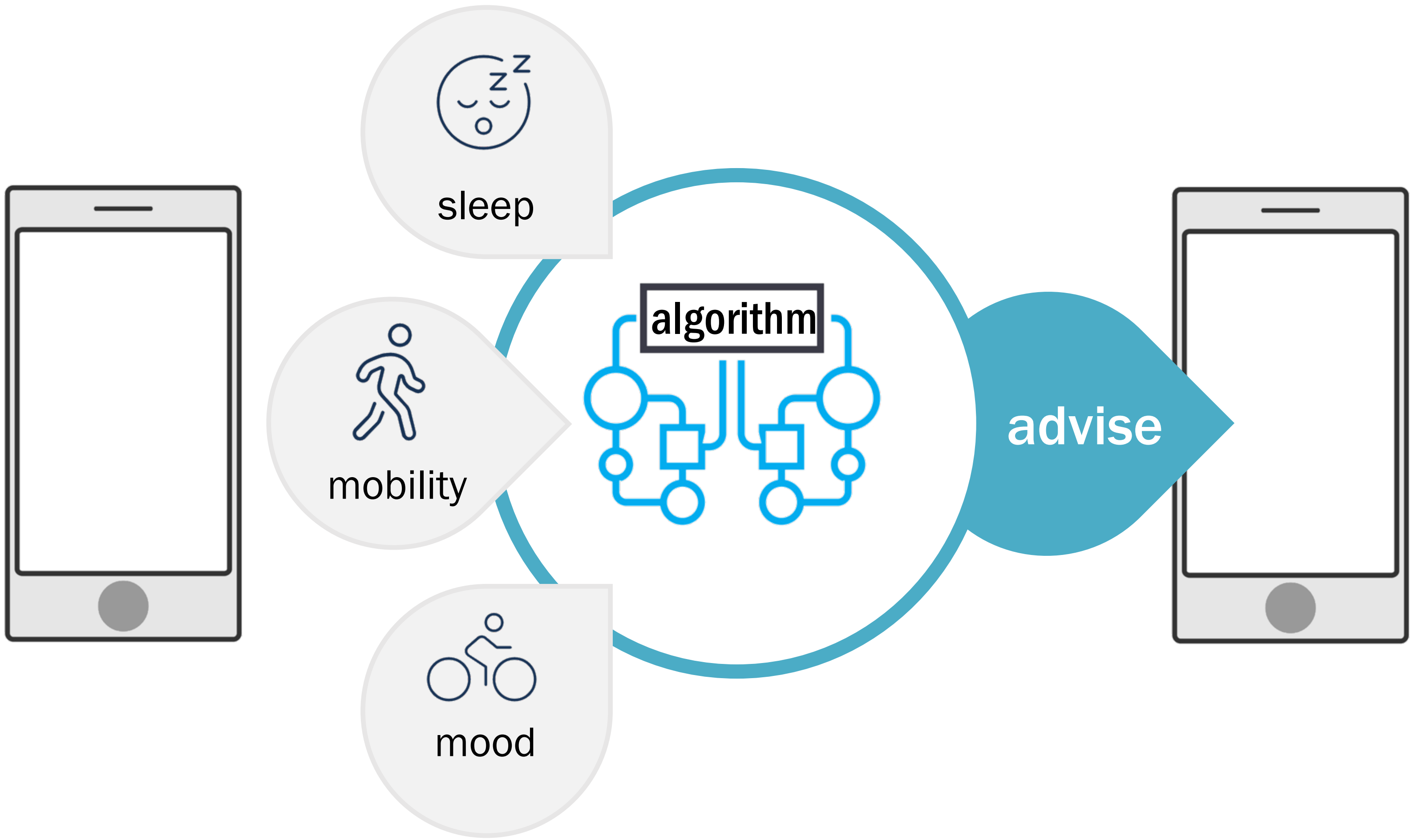
JITAIs

Micro Interventions

Single Interventions

Indirect Interventions

Future Challenges

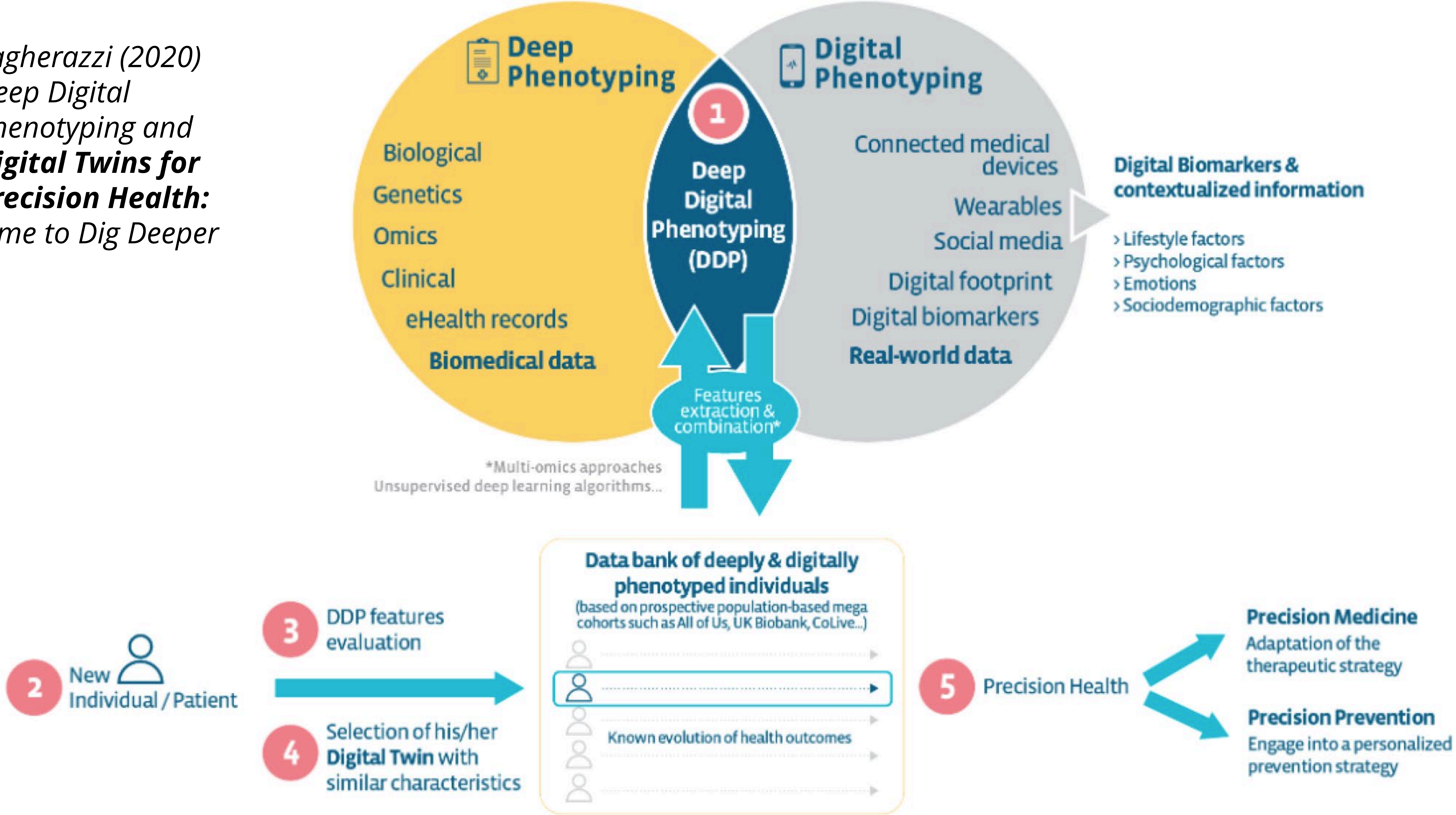


- External validation
- Trust
- Acceptation
- Literacy
- Privacy
- Empowerment
- Self-management
- Implementation
- Reflection & critical appraisal

Thank you for your attention!

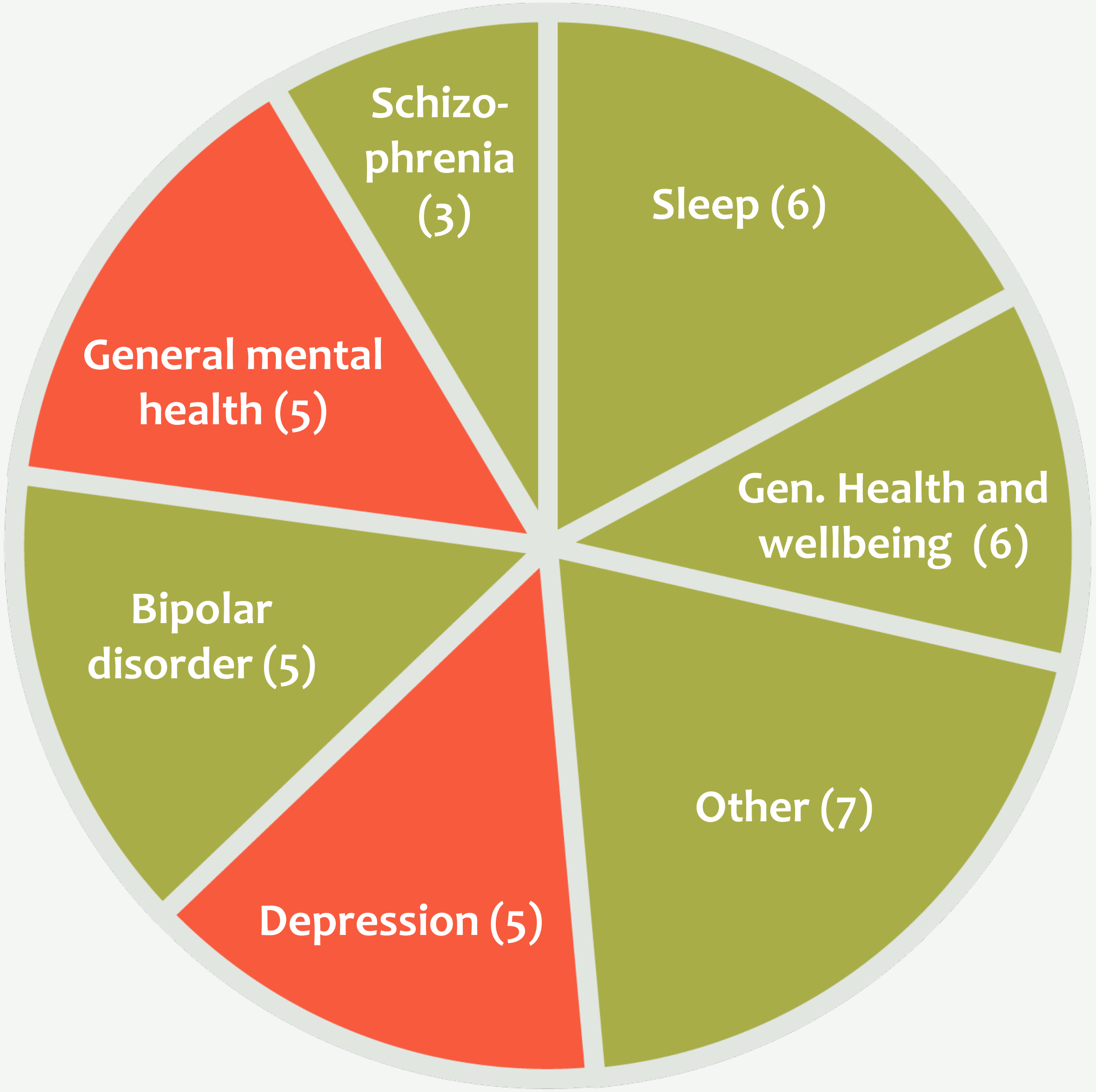
h.riper@vu.nl

Fagherazzi (2020)
Deep Digital Phenotyping and ***Digital Twins for Precision Health:*** *Time to Dig Deeper*



Systematic review on smartphone-based passive sensing studies.

N=35 studies



Cornet & Holden (2018) *Journal of Biomedical Informatics*

Results

a.
- N =10
- pre-post design
- small sample sizes (8-48)

b.
- prediction accuracy of mood 55% - 86%

c.
- 2 replications
- 2 + JITI’s
- only 1 clinical sample
- healthy students

d.
- ML methods compared
- Outcomes v GS or EMA
- AI journals ++

frontiers in Psychology

ORIGINAL RESEARCH
published: 14 May 2019
doi: 10.3389/fpsyg.2019.01065

Validating Automated Sentiment Analysis of Online Cognitive Behavioral Therapy Patient Texts: An Exploratory Study

Simon Provoost[1], Jeroen Ruwaard[2,3], Ward van Breda[4], Heleen Riper[1,2,3,5] and Tibor Bosse[6]*

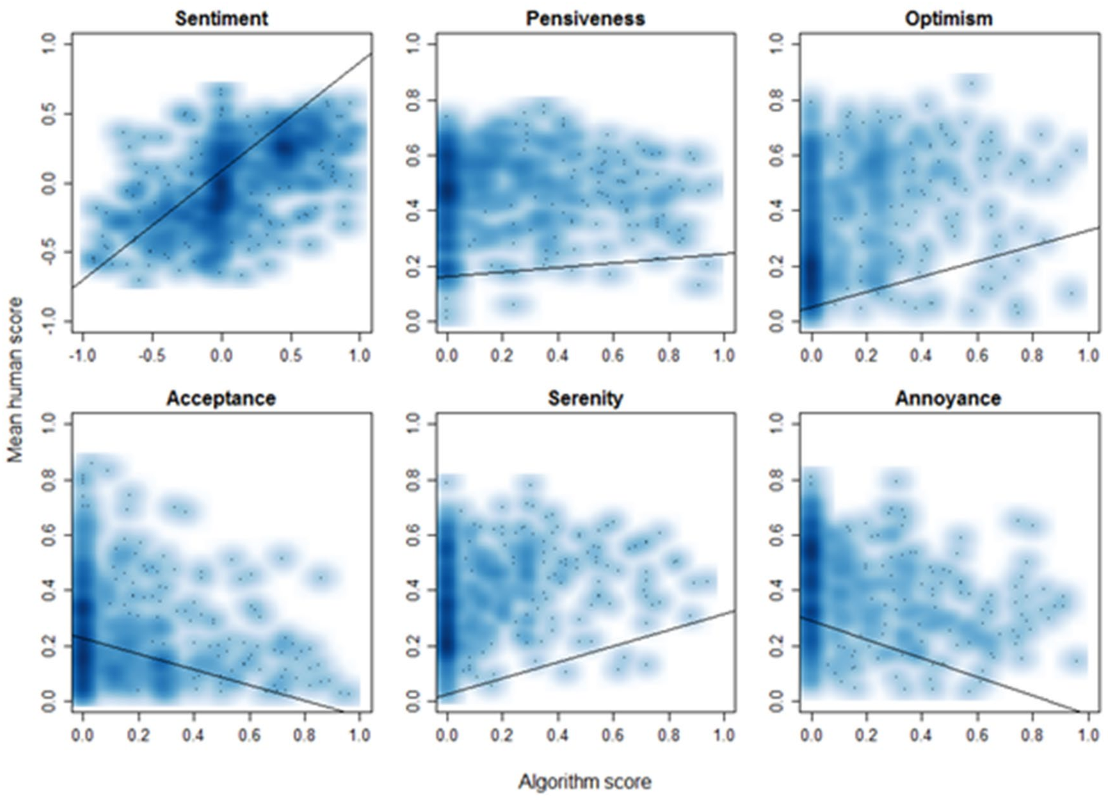
sentimentics™
remarkable text analytics

Ward van Breda, VU

Kooistra, Wiersma, Ruwaard, Neijenhuijs, Lokkerbol, van Oppen, Smit, Riper (2019, accepted JMIR) Costs and effectiveness of blended versus standard cognitive behavioral therapy for depressed outpatients in routine specialized mental healthcare:
a pilot randomized controlled trial.

Results

Intra-class correlation of algorithm versus human judgment was moderate, but only for sentiment.



The intra-class correlation among human judges, however, was not much better.

	Human – Algorithm	Human – Human
Sentiment	.55 (moderate)	.58 (moderate)
Pensiveness	.12 (low)	.22 (low)
Annoyance	.00 (low)	.28 (low)
Optimism	.23 (low)	.46 (low)
Acceptance	.00 (low)	.34 (low)
Serenity	.14 (low)	.24 (low)