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Personalising and Scaling Mental Health Care and Mental Health Research by Digital Means

Prof. Dr. Harald Baumeister

Keynote Presentation

ICT4AWE

Angers, France, April 24th 2024

**Ulm University –
Faculty of Engineering, Computer Science
and Psychology**

**Faculty Research
Priorities:**

➜ **Cognitive Systems &
Human-Technology**

➜ **Smart Sensing Systems**

**Psychology Research
Priorities:**

➜ **Human & Health**

➜ **Human Behavior in
Social Context**

Department of Clinical Psychology and Psychotherapy:

➜ **Digital Behavioral and Mental Health**

➜ **Psychotherapy Process Research, Somato-Pschology, Health
Services Research**

➜ **Part of German Centres for Mental Health (DZP) and Child and
Adolescent Health (DZKJ)**

Digital Mental Health

Basic Research
- Etiology ad Pathology
- Nosology and Classification
- Epidemiology
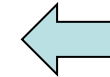
Digital Phenotyping / EMA / Smart Sensing

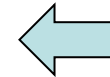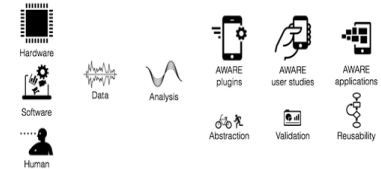**Diagnostics, Intervention, Health Services Reserach**

Diagnostics
- Patient Reported Outcome/Experience (PROM/PREM)
- Screening of Mental Disorders
- Psycho-Social State/Traits
- RDoC / HiTOP

Server-based PROM/PREM Computer-adaptive Testing (CAT) Clinical Decision Support Systems (CDSS)
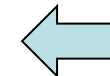

Interventions
- Mental Burden and Disorders
- Behavioral Medicine
- Prevention and Health Promotion
- Comptence and Skill Training
- Complex Interventions

Internet- und mobile-based (IMI) Blended Care Virtual Reality AI-based Innovations Videoconference-based Therapy

eSano
online-trainings

Digital (Self-Help) Health Interventions

- Acceptable, efficacious and effective for a multitude of mental disorders and somatic diseases as well as in the context of prevention and health promotion

- Opens new ways of health promotion and mental health treatments

- Additional health care access for difficult to reach populations and those who refrain from on-site treatment for various reasons

- Scalable approach

Ebert & Baumeister, Springer, 2023

German S3-Guideline Depression
– Digital Interventions –

Mild Depression:

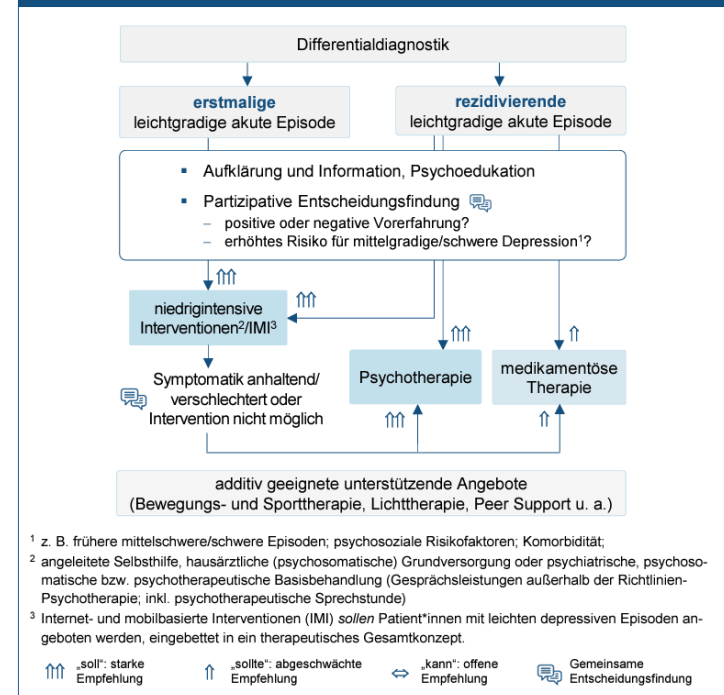First Level Recommendation next to Psychotherapy and to be prefered over Psychopharmacotherapy

Moderate-Severe

In addition to on-site psychotherapy and/or psychopharmacotherapy

NVL Unipolare Depression
Kurzfassung – Version 3.2

NATIONALE VERSORGUNGS LEITLINIEN

Abbildung 11: Akuttherapie leichtgradiger depressiver Störungen

Differentialdiagnostik

erstmalige
leichtgradige akute Episode

rezidivierende
leichtgradige akute Episode

- Aufklärung und Information, Psychoedukation
- Partizipative Entscheidungsfindung
  - positive oder negative Vorerfahrung?
  - erhöhtes Risiko für mittelgradige/schwere Depression[1]?

niedrigintensive Interventionen[2]/IMI[3]

Symptomatik anhaltend/ verschlechtert oder Intervention nicht möglich

Psychotherapie

medikamentöse Therapie

additiv geeignete unterstützende Angebote
(Bewegungs- und Sporttherapie, Lichttherapie, Peer Support u. a.)

[1] z. B. frühere mittelschwere/schwere Episoden; psychosoziale Risikofaktoren; Komorbidität;
[2] angeleitete Selbsthilfe, hausärztliche (psychosomatische) Grundversorgung oder psychiatrische, psychoso-matische bzw. psychotherapeutische Basisbehandlung (Gesprächsleistungen außerhalb der Richtlinien-Psychotherapie; inkl. psychotherapeutische Sprechstunde)
[3] Internet- und mobilbasierte Interventionen (IMI) sollen Patient*innen mit leichten depressiven Episoden an-geboten werden, eingebettet in ein therapeutisches Gesamtkonzept.

„soll": starke Empfehlung   „sollte": abgeschwächte Empfehlung   „kann": offene Empfehlung   Gemeinsame Entscheidungsfindung

BÄK et al. 2022

https://diga.bfarm.de/de/verzeichnis

BfArM DIGA Register
(N=63, 35 permanent, 22 preliminary, 6 delisted; April. 2024)

Complex Intervention Example:
Blended Outpatient Psychotherapy

PSYCHOnlineTHERAPY

**as blended therapy approach
for outpatient psychotherapy**

**Funded by Innovationsausschuss
(GBA)**

Website:
➔ https://www.psychonlinetherapie.de

eSano Online-Intervention:
PSYCHOnlineTHERAPY
Examined for Depression and Anxiety
Realised for ICD-10 F1-F6

Social Media:
Facebook/Instagram
@psychonlinetherapie

Twitter
@psychONtherapie
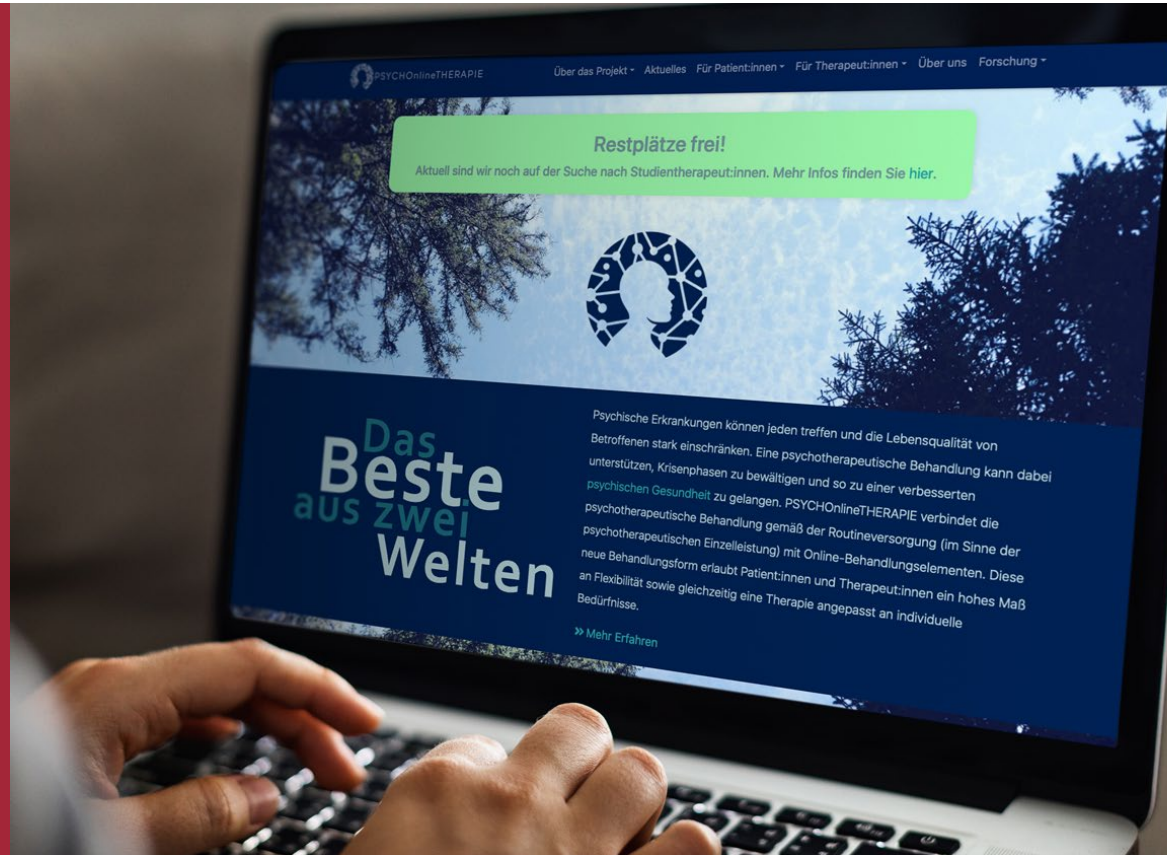
Intervention Examples: Children and Adolescents

iChimps
Cognitive-behavior therapy (CBT) and depth psychology therapy based intervention for CaA of parents with mental disorders

ProTransition
CBT-based intervention to support health-care system transition of youth with mental disorders

youthCOACH$_{CD}$: **CBT-based intervention for adolescents with somatic diseases and depression / anxiety**

Intervention Examples: Somatic Diseases

ACTonDiabetes:
Acceptance and Commitment Therapy (ACT)-based intervention for people with diabetes mellitus

ACTonPain
ACT-based intervention for people with chronic pain

ACTonCancer
ACT-based intervention for people with cancer

E-Health Plattform – „eSano"

eSano-Platform
web-/browser-based
data-bank (*MySQL*)
web-interface (*PHP*, *Laravel*)

eSano online-trainings

Content Management System

Development of interventions (*Vue.js*)

E-Coach Platform

Patient administration and eCoaching (*Angular*.js)

Patient Platform

Responsive design intervention platform (Web,, Android, iOS) based on cross-platform-app (*Ionic*)

MDR
§ §
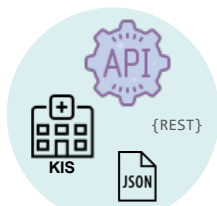
Interface

Mobile Sensing

Machine Learning

Security & Privacy

https://esano.klips-ulm.de/de/it-plattform/; Kraft et al. EMBC 2021; Idrees et al. WiMob 2022

Communication Process ➡️

Kraft et al., 2021
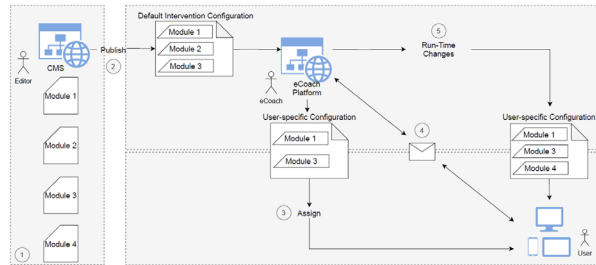
Fig. 3. Guidance process in eSano that spans the different subsystems
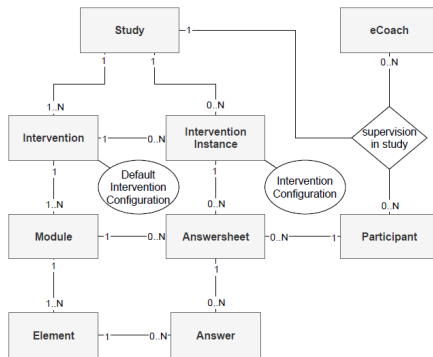
MDR conform development ➡️

Holfelder et al., 2021

Figure 1. Waterfall (V-model) software development process model.

Data Processing ⬅️

Kraft et al., 2021

Fig. 2. Simplified entity-relationship model (ERM) of the eSano data model
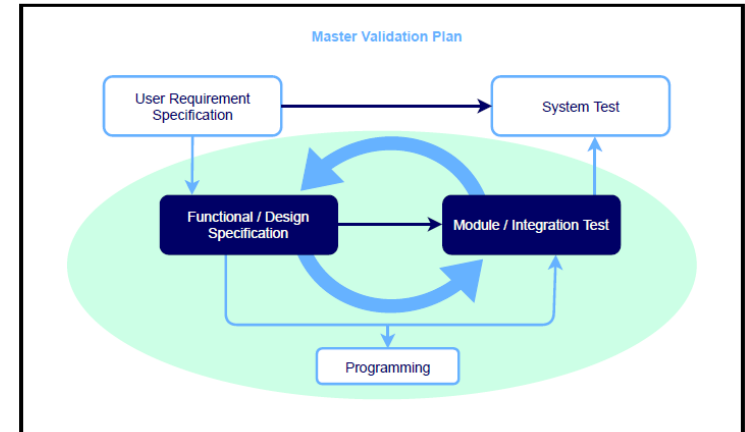
Figure 2. Process model of agile software development.

Kraft et al. IEEE EMBS 2021; Holfelder et al. J, 2021; Idrees et al. IEEE WiMob 2022
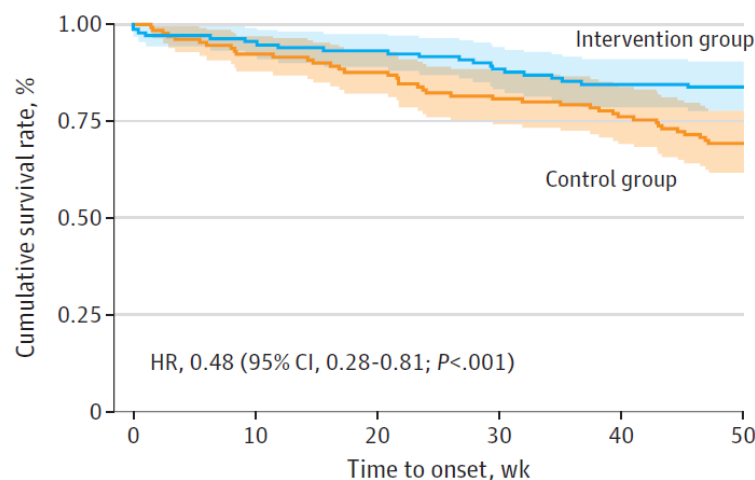
Intervention development: YouthCOACH$_{CD}$
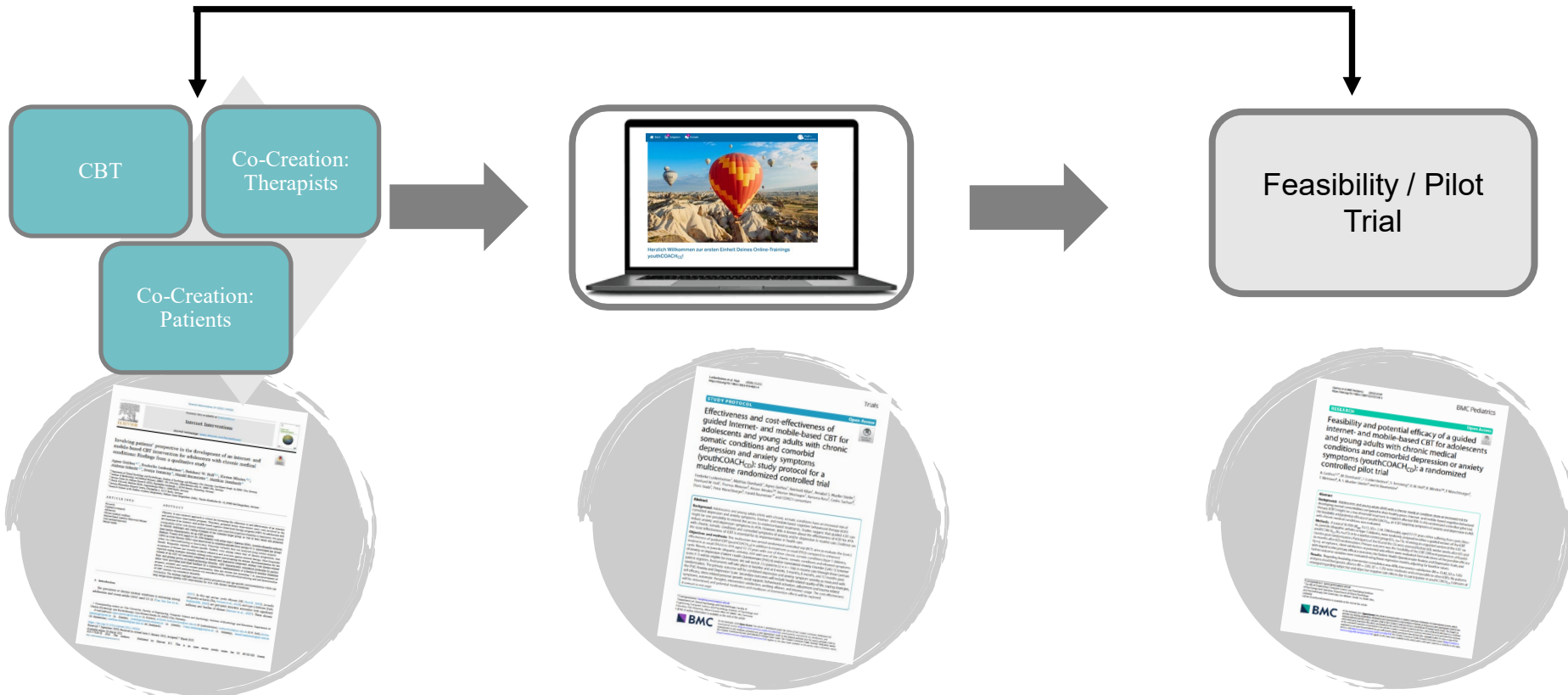
Geierhos et al. 2021, 2022; Lunkenheimer et al. 2020

PROD - Prevention in People with Chronic Back Pain and Subthreshold Depression

Figure 2. Kaplan-Meier Survival Curve of Time to Onset of Major Depressive Disorder

Shading indicates 95% CI.

Incidence (12 months):

TAU   = 28.1%

TAU plus IMI   = 14.1%

Hazard Ratio (N=295):

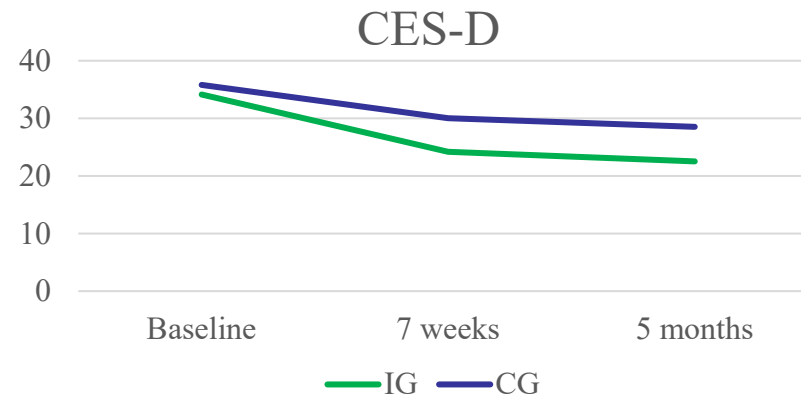0.48 (95%CI 0.28 – 0.81)

NNT: 2.84 (95%CI 1.79-9.44)

Sander et al., JAMA Psychiatry 2021

GEFÖRDERT VOM

DFG Deutsche Forschungsgemeinschaft

Bundesministerium für Bildung und Forschung

WARD-BP - Treatment in People with Chronic Back Pain and Depression

HAM-D
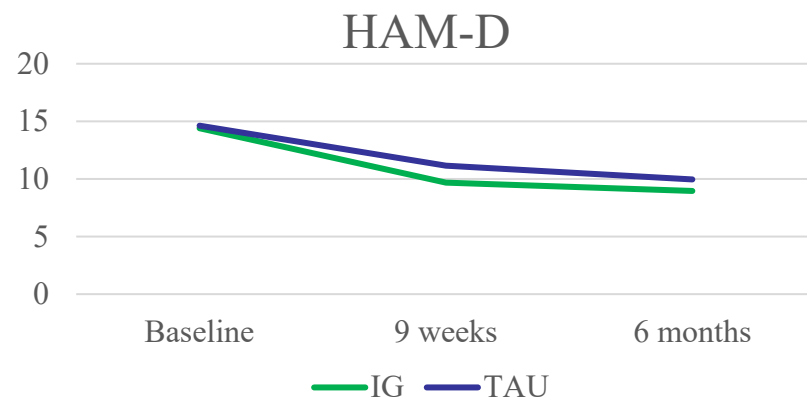
	IG (n = 104)	CG (n = 105)	ITT ß
Baseline	14.4 (5.45)	14.61 (5.32)	
7 weeks	9.67 (6.41)	11.14 (7.26)	-0.19 (-0.43;0.05)
5 months	8.97 (6.44)	9.95 (7.13)	-0.14 (-0.40;0.12)

Baumeister et al., Psychother Psychosom 2022

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

Psychotherapy Waiting Time Depression Intervention

CES-D

	IG (n = 104)	CG (n = 105)	ITT Cohens d
Baseline	34.1 (0.8)	35.8 (0.8)	
7 weeks	24.2 (1.4)	30.0 (1.3)	0.55
5 months	22.5 (1.6)	28.5 (1.4)	0.52

Kraemer et al., Psychother Psychosom 2021

YouthCoach$_{CD}$ – Digital Intervention for Adolescents with somatic diseases and depression / anxiety

PHQ-ADS
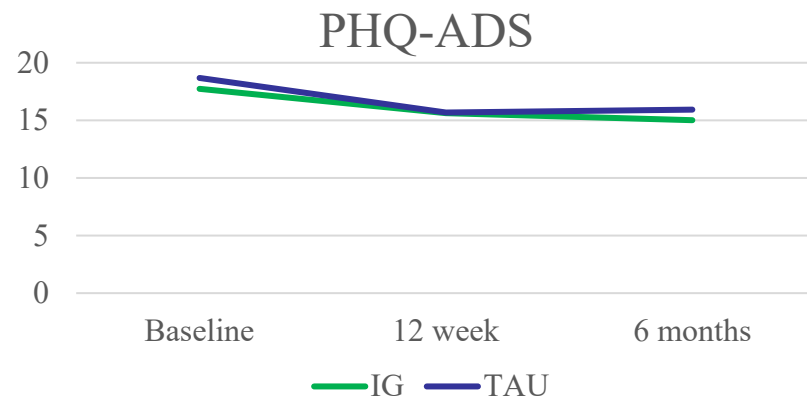
	IG (n = 112)	CG (n = 108)	ITT ß
Baseline	17.73 (7.92)	18.67 (8.56)	
12 weeks	15.62 (9.62)	15.66 (8.77)	0.048; p = 0.421
6 months	15.01 (7.90)	15.92 (9.01)	-0.020; p = 0.739

Lunkenheimer, Domhardt et al., in progress; Dülsen & Baumeister European Child & Adolescent Psychiatry 2024

Personalising and Scaling

Moderators & Mediators

AI-Innovations

Implementation

Differential Indication:
predictors, moderators, active components, mechanisms of change

For whom does it work when and why best?

Moderators of digital interventions in subthreshold depression – results of an IPD-MA

Table 4. Results from separate multilevel regression analyses on the effects of putative moderators on differential change in depression severity from baseline to posttreatment assessment

Baseline variable	Interaction: baseline variable × treatment condition						
	estimate	SE	t value	p (<|t|)	τ^2_0	τ^2_1
Age	−0.066	0.033	−2.002	0.045	2.812	1.972	<- Older Age
Gender	−0.799	0.784	−1.02	0.308	2.568	1.998	
Relationship	−0.549	0.707	−0.776	0.438	2.506	2.281	
Employment	0.105	0.903	0.116	0.908	2.612	2.256	
Previous psychotherapy	0.816	0.960	0.849	0.396	2.671	2.365	
Depression medication	0.594	0.090	0.600	0.548	2.671	2.312	
Comorbidities	−0.816	0.846	−0.965	0.335	2.825	1.904	
Chronic medical conditions	−0.306	1.392	−0.22	0.826	2.639	2.197	
Comorbid anxiety	−0.950	0.905	−1.049	0.295	2.996	2.086	
Initial symptom severity	−0.182	0.069	−2.641	0.008	2.197	1.391	<- Baseline Severity
Format	−1.797	0.944	−1.905	0.057	2.655	0.786	
Number of sessions	−0.001	0.256	−0.007	0.994	2.580	2.443	
Education	−0.566	0.605	−0.936	0.350	2.597	2.621	

All analyses were controlled for initial depressive symptom severity. SE, standard error; τ^2_0, intercept variance; τ^2_1, slope variance; gender (0 = male, 1 = female, 2 = other); relationship (0 = single/divorced/separated/widowed, 1 = married/in a relationship); employment (0 = no, 1 = yes); previous psychotherapy (0 = no, 1 = yes); depression medication (0 = no, 1 = yes), comorbidities (0 = no, 1 = yes), chronic medical conditions (0 = no, 1 = yes), comorbid anxiety (0 = no, 1 = yes), format (0 = unguided, 1 = guided); education (0 = no = 0–5 years, 1 = low = 6–9 years, 2 = middle = 10–12 years, 3 = high = 13–17 years, 4 = very high = 18+ years).

Reins et al., Psychother Psychosom 2020

Psychological (in-)flexibility moderats effectiveness

ACTonPain

Figure 2. Visualizations of the results testing baseline psychological inflexibility as a moderator of the treatment outcome pain interference between waitlist and unguided Internet-based ACT. The outcome (Y-axis) is displayed for three different levels (sample mean ± 1 standard deviation) of psychological inflexibility (X-axis). Note: AAQ-II = Acceptance and Action Questionnaire; iACT = Internet-based Acceptance and Commitment Therapy; MPI = Pain interference scale of the Multidimensional Pain Inventory; t0 = baseline; t1 = 9-weeks after randomization; t2 = 6-months after randomization.

Figure 1. Visualizations of the results testing baseline psychological inflexibility as a moderator of the treatment outcome pain interference between waitlist and guided Internet-based ACT. The outcome (Y-axis) is displayed for three different levels (sample mean ± 1 standard deviation) of psychological inflexibility (X-axis). Note: AAQ-II = Acceptance and Action Questionnaire; iACT = Internet-based Acceptance and Commitment Therapy; MPI = Pain interference scale of the Multidimensional Pain Inventory; t0 = baseline; t1 = 9-weeks after randomization; t2 = 6-months after randomization.

Article

Baseline Psychological Inflexibility Moderates the Outcome Pain Interference in a Randomized Controlled Trial on Internet-based Acceptance and Commitment Therapy for Chronic Pain

Thomas Probst [1,*], Harald Baumeister [2], Lance M. McCracken [3,4] and Jiaxi Lin [5]

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4 INPUT Pain Management Guy's and St Thomas' NHS Foundation Trust London, London SE1 7EH, UK
5 Department of Sports and Sport Science, University of Freiburg, 79098 Freiburg, Germany; jiaxi.lin@sport.uni-freiburg.de
* Correspondence: thomas.probst@donau-uni.ac.at; Tel.: +43-(0)2732-893-2679

Abstract: This study re-investigated data of a randomized controlled trial on Internet-based Acceptance and Commitment Therapy for chronic pain (ACTonPain). Baseline psychological inflexibility was examined as a moderator of the outcome pain interference. In the ACTonPain trial, participants with chronic pain were randomized to one of three conditions: guided Internet-based ACT ($n = 100$), unguided Internet-based ACT ($n = 101$), and waitlist ($n = 101$). Moderation analyses were performed with the SPSS macro PROCESS. Pain interference according to the Multidimensional Pain Inventory (MPI) was the primary outcome in this trial, and the potential moderator psychological inflexibility was measured with the Acceptance and Action Questionnaire (AAQ-II). Psychological inflexibility at baseline moderated the outcome between guided Internet-based ACT and waitlist 9-weeks as well as 6-months after randomization. (both $p < 0.05$). Between unguided Internet-based ACT and waitlist, psychological inflexibility moderated the outcome 6-months after randomization ($p < 0.05$). Internet-based ACT was superior to waitlist for participants with less psychological inflexibility at baseline, but Internet-based ACT became increasingly comparable to waitlist at higher AAQ-II baseline values. Future research should investigate whether the results can be replicated in more individualized and tailored face-to-face settings.
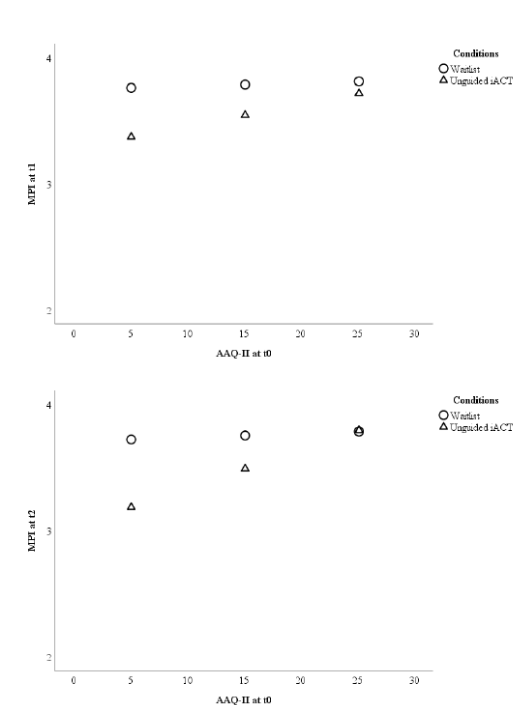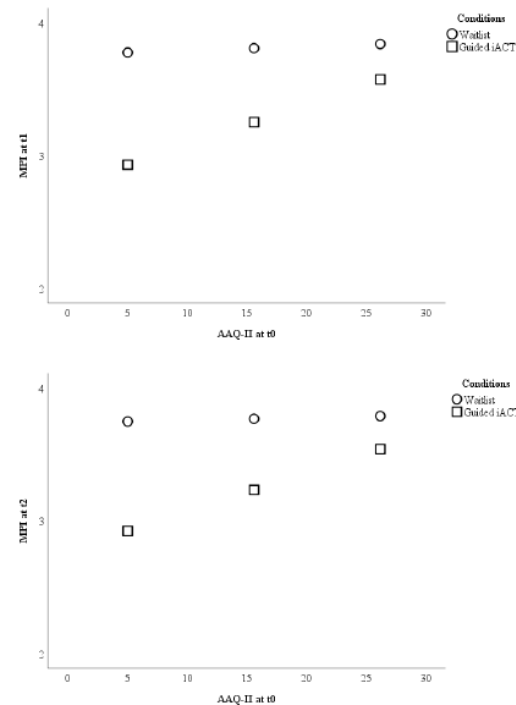
Keywords: acceptance and commitment therapy; psychological inflexibility; chronic pain

1. Introduction

Chronic pain (CP) is a disorder with a pooled prevalence rate of 31% [1] and it is constantly one of the top causes of years lived with disability [2]. Numerous psychological variables appear to contribute to the process of how pain leads to disability, including self-efficacy, emotional distress, and fear [3]. Psychological therapies have been shown to be effective to improve anxiety, depression, catastrophic thinking, disability, and sometimes also pain [4].

A psychotherapy increasingly gaining interest in the treatment of CP is Acceptance and Commitment Therapy (ACT), a contextual form of Cognitive and Behavioral Therapy (CBT). In ACT, psychological flexibility and its opposite psychological inflexibility are central concepts [5]. The six

Probst et al., J Clin Med 2019

Active Component: Guidance
Digital Depression Intervention Metaanalyse

83 studies, 88 articles, 15.530 participants, 95% adult trials (Ø 41 years), 70% female, mild-moderate depression at average (Ø 12.9 PHQ-9), 27% trial on MDD, 74% iCBT-based, guided in 52%, tech-guided in 28% of cases, Ø 7 modules, 90% on web-based interventions

Guidance:

- Unguided $g = .34 \ (.24 \ ; \ .45)$

- Tech-Guided $g = .46 \ (.29 \ ; \ .62)$

- Human Guided $g = .63 \ (.50 \ ; \ .76)$

Not associated with

- Communication way (synchronous, asynchronous)

- Qualification level (high, low) and

- Duration (Ø 81 Minuten) of human guidance

Moshe et al. Psychological Bulletin 2021

Active Component: Delivery Method / Device

Depression:[1]

- Web-based   g = .53 95%CI (.43; .62)
- Mobile-based   g = .39 95%CI (-.27; 1.06)

Mobile-based across Conditions:[2]

- Depression   g = .33 (.10; .57)
- Anxiety   g = .30 (-.10; .7)

App-based adjunctive to interventions:[3]

- Depression   g = .17 (.02; .33)
- Anxiety   g = .80 (.06; 1.54)
- Bipolar Disorders   g = .20 (.02; .38)
- Eating Disorders   g = -.02 (-.44; .4)

1 Moshe et al. Psychological Bulletin 2021; 2 Weissel et al. npj Digital Medicine, 2019; 3 Fuhrmann et al. Internet Intervention 2023

MHAD (http://mhad.science)
App Quality Rating Data Base

	N	Functionality	Aesthetics	Engagement	Content	Subjective	Perceived Impact
Mindfulness	192	4,18	3,79	3,45	3,24		
Borderline	17	3,74	2,99	2,86	3,34		
Depression	38	3,12	3,01	2,89	2,98		
Gastrointestinal	109	4,08	3,19	2,47	1,89	2,16	2,33
Insomnia	55	4,01	3,24	3,06	3,51		
Child and Adolescent	15	3,81	3,78	3,34	2,34	3,13	2,80
Oncology	78	4,21	3,41	2,92	2,67		
PTSD	69	3,82	3,36	3,03	3,22	2,54	2,59
Back Pain	20	3,90	3,40	3,10	3,30		
Pain	218	3,66	3,11	2,81	2,93	2,19	2,06
Older Adults	83	3,99	3,60	3,25	2,02		
Sexuality	6	3,71	3,58	3,25	3,60	2,52	3,15
Physical Activity	312	4,35	3,65	3,19	3,23	2,34	2,32
Average	1212	3,89	3,39	3,05	2,94	2,48	2,54

Paganini et al. JMIR mHealth and uHealth 2023; Simon et al. J Sleep Research 2023; Messner et al. JMIR 2022; Steubl et al. BPD & Emot Dysr 2022; Gerner et al. JMIR mHealth and uHealth 2022; Geirhos et al. Scientific Report 2022; Muehlmann et al. Z Sex Forsch 2022; Domhardt et al. CaA Psychiatry Mental Health 2021; Schultchen et al. Int J Behav Med 2021; Mack et al. IJERPH, 2021; Sander et al. Front Digital Health 2021; Paganini et al. JMIR mHealth and uHealth, 2021; Terhorst et al. Int Intervent 2021; Portenhauser et al. JMIR Aging 2021; Sander et al. Europ J Psychotraum 2021; Terhorst et al. Verhaltenstherapie 2018

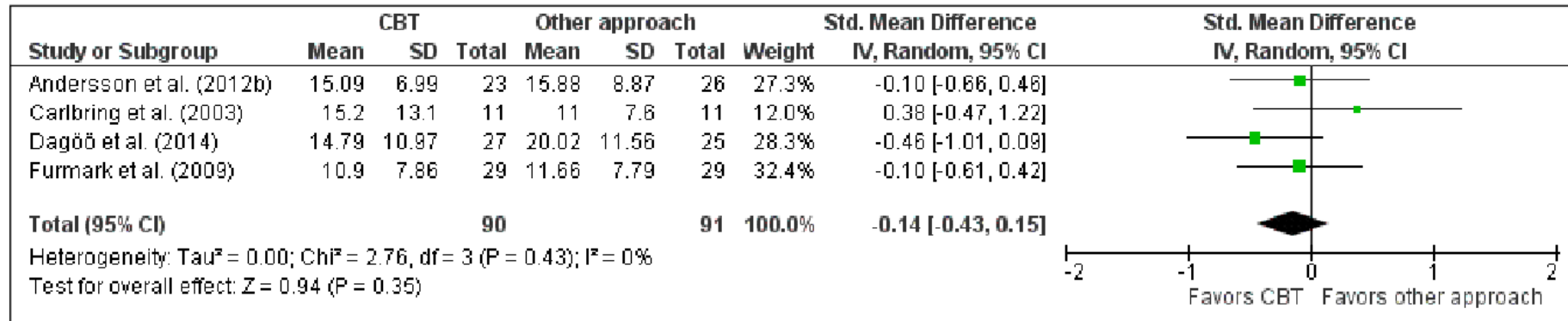# Active Components in Digital Anxiety Interventions - Metaanalyse (Domhardt et al., Depression & Anxiety 2019)

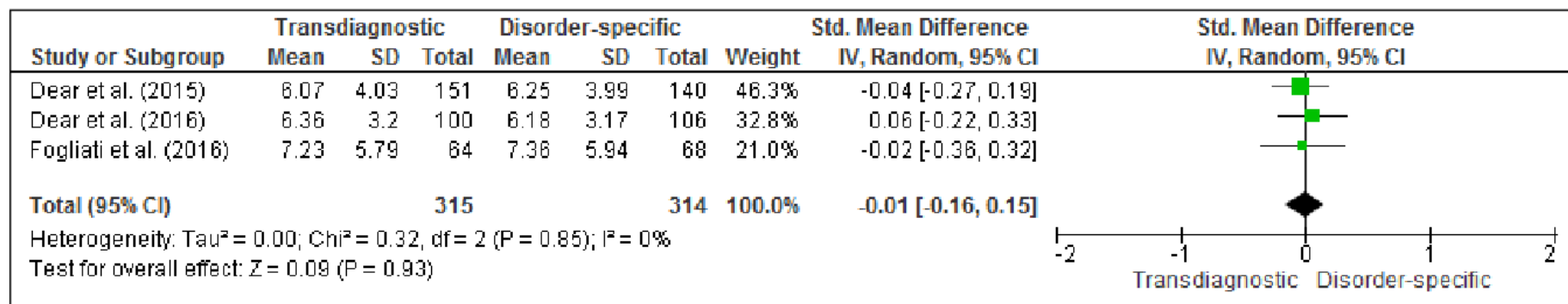| Study or Subgroup	CBT Mean	SD	Total	Other approach Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Andersson et al. (2012b)	15.09	6.99	23	15.88	8.87	26	27.3%	-0.10 [-0.66, 0.46]
Carlbring et al. (2003)	15.2	13.1	11	11	7.6	11	12.0%	0.38 [-0.47, 1.22]
Dagöö et al. (2014)	14.79	10.97	27	20.02	11.56	25	28.3%	-0.46 [-1.01, 0.09]
Furmark et al. (2009)	10.9	7.86	29	11.66	7.79	29	32.4%	-0.10 [-0.61, 0.42]
Total (95% CI)			90			91	100.0%	-0.14 [-0.43, 0.15]

Heterogeneity: Tau² = 0.00; Chi² = 2.76, df = 3 (P = 0.43); I² = 0%
Test for overall effect: Z = 0.94 (P = 0.35)

Favors CBT   Favors other approach

Fig. 1: CBT vs. Other Approaches

Study or Subgroup	Transdiagnostic Mean	SD	Total	Disorder-specific Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Dear et al. (2015)	6.07	4.03	151	6.25	3.99	140	46.3%	-0.04 [-0.27, 0.19]
Dear et al. (2016)	6.36	3.2	100	6.18	3.17	106	32.8%	0.06 [-0.22, 0.33]
Fogliati et al. (2016)	7.23	5.79	64	7.36	5.94	68	21.0%	-0.02 [-0.36, 0.32]
Total (95% CI)			315			314	100.0%	-0.01 [-0.16, 0.15]

Heterogeneity: Tau² = 0.00; Chi² = 0.32, df = 2 (P = 0.85); I² = 0%
Test for overall effect: Z = 0.09 (P = 0.93)

Transdiagnostic   Disorder-specific

Fig. 2: Transdiagnostic vs. Disorder Specific

Active Component – Network-MA iCBT Depression

	Depression severity (iMD of PHQ–9 scores), median (95% CrI)
Age	0·19 (–0·09 to 0·47)
Baseline depression, PHQ–9 scores	2·59 (2·32 to 2·85)
Gender*	–0·03 (–0·28 to 0·18)
Relationship†	–0·12 (–0·33 to 0·12)
Waiting component	0·42 (–0·75 to 1·53)
Non-specific treatment effects	–1·41 (–2·52 to –0·30)
Psychoeducation about depression	0·02 (–0·86 to 0·93)
Cognitive restructuring	0·30 (–0·87 to 1·41)
Behavioural activation	–1·83 (–2·90 to –0·80)
Interpersonal skills training	–0·54 (–1·59 to 0·52)
Problem solving	–0·64 (–1·41 to 0·09)
Relaxation	1·20 (0·17 to 2·27)
Third-wave components	–0·53 (–1·55 to 0·49)
Behaviour therapy for insomnia	–1·82 (–3·92 to 0·26)
Relapse prevention	0·35 (–0·69 to 1·32)
Homework required	0·31 (–0·69 to 1·35)
Initial face-to-face contact	0·85 (–1·80 to 3·41)
Automated encouragement to proceed with iCBT	–0·26 (–1·13 to 0·60)
Human encouragement to proceed with iCBT	–0·29 (–1·17 to 0·58)
Therapeutic guidance for iCBT	0·01 (–0·88 to 0·89)

<- unspecific effect

<- behavior change

<- relaxation

Furukawa et al., Lancet Psychiatry 2021

Active Component: Cultural Adaptation in Mental Health – Systematic Review
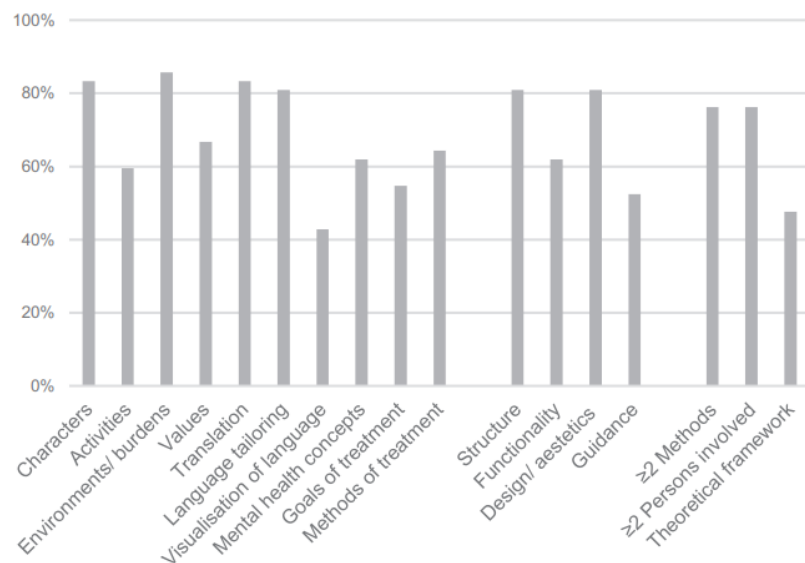
Fig. 2 Taxonomy of cultural adaption of internet- and mobile-based interventions (IMI). Percentages of the 42 included IMI that fulfilled the respective content, methodological, and procedural components of the taxonomy.
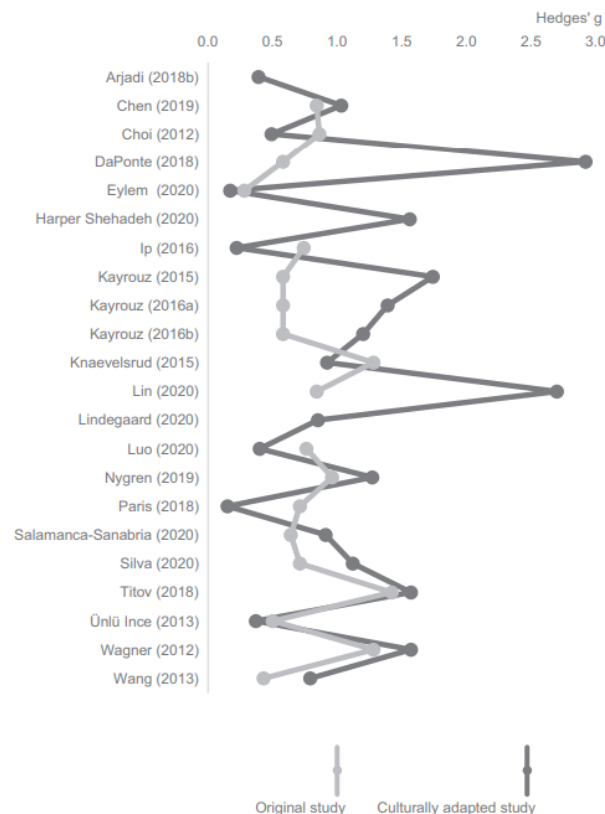
Fig. 3 Effect sizes (Hedges' _g_) of the culturally adapted versus original internet- and mobile-based interventions. Twenty-two included articles provided relevant information on the effect of their intervention. If more than one primary outcome was reported, the effect size of the Patient Health Questionnaire[102] is illustrated. Both single group studies and randomised controlled trials are included. Full information on the respective effect sizes can be found in Table 4.

Spanhel et al., NPJ Digital Medicine 2021

Active Component: Cultural Adaptation in Health Promotion – Meta-Analysis
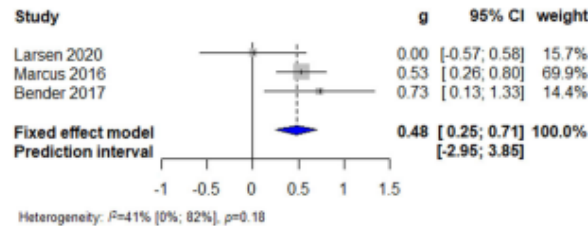
Fig. 6 **Fixed effects meta-analysis of culturally adapted IMI for physical activity vs. active control conditions.** Forest plot presenting fixed effects meta-analysis of culturally adapted IMI for physical activity vs. active controls.
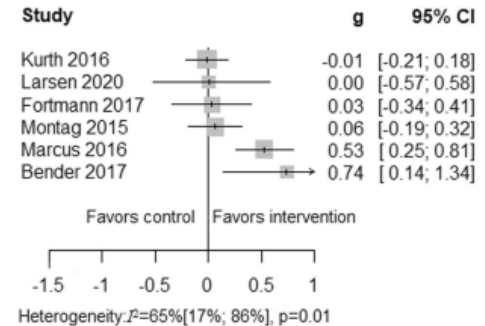
Fig. 3 **Summary of culturally adapted IMI of health promotion vs. active controls in the long-term.** Due to substantial heterogeneity among the culturally adapted IMI of health promotion vs. active controls in long-term meta-analytical pooling did not perform.

Fig. 4 **Summary of culturally adapted IMI of health promotion vs. active controls in the short-term.** A summary plot of effect sizes of four studies of culturally adapted IMI of health promotion vs. active controls in short-term are presented.
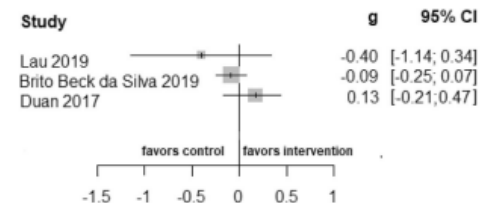
Fig. 5 **Summary of culturally adapted IMI of health promotion vs. passive controls.** Due to few numbers of studies (two studies reported data in the long-term, two in the short-term, while one study reported dichotomous outcome) comparing culturally adapted IMI to a passive control group, meta-analytic pooling did not perform.

- 13 trials included: DI adapted vs. Not adapted

- Significant benefit regarding physical activity (g = 0.48; KI: 0.26;0.71)

- Non-significant regarding all other health promotion domains

=> **Superiority of cultural adapted interventions in question**

Balci et al., NPJ Digital Medicine 2022

Active Component: Persuasive Design

Effectiveness of Smartphone Apps for
Depression / Anxiety related to Persuasiveness

Fig. 3   Random effects meta-analysis in RCTs of app efficacy comparing change in anxiety or depression symptoms in apps vs. control.
Forest plot of random effects meta-analysis in RCTs of app efficacy comparing change in anxiety or depression symptoms in apps vs. control.
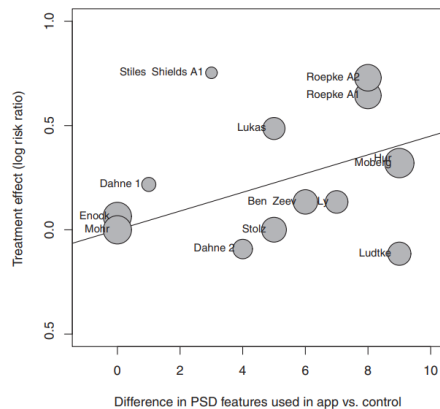
Fig. 4   Mixed effects meta-regression analysis of difference in PSD features and efficacy for app vs control. Bubble plot of mixed effects meta-regression analysis of difference in PSD features and efficacy for app vs control.

Fig. 5   Mixed effects meta-regression analysis of difference in PSD features and study completion rate for app vs control. Bubble plot of mixed effects meta-regression analysis of difference in PSD features and study completion rate for app vs control.

Wu et al. NPJ Digital Medicine 2021
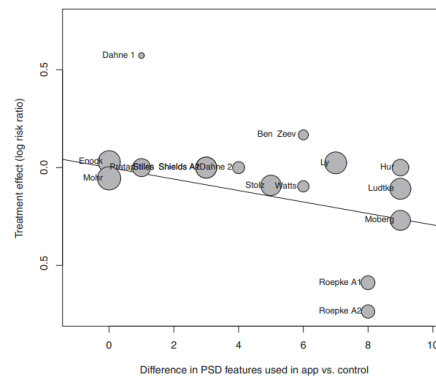
Table 4. Frequency of PSD features.

Feature	App with feature	% apps with feature
Reduction	26	86.7%
Tunneling	11	36.7%
Tailoring	12	40.0%
Personalization	16	53.3%
Self-monitoring	21	70.0%
Simulation	1	3.3%
Rehearsal	12	40.0%
Total primary task support features across all apps	**99**	
Praise	7	23.3%
Rewards	7	23.3%
Reminders	15	50.0%
Suggestion	16	53.3%
Similarity	5	16.7%
Liking	6	20.0%
Social role	2	6.7%
Total dialogue support features across all apps	**58**	
Social learning	3	10.0%
Social comparison	2	6.7%
Normative influence	1	3.3%
Social facilitation	5	16.7%
Cooperation	0	0%
Competition	0	0%
Recognition	0	0%
Total social support features across all apps	**11**	
Trustworthiness	7	23.3%
Expertise	7	23.3%
Surface credibility	10	33.3%
Real-world feel	1	3.3%
Authority	2	6.7%
Third party endorsements	0	0%
Verifiability	0	0%
Total credibility support features across all apps	**27**	

Persuasive Design

PD optimised procrastination intervention (5 CBT-modules): Non-inferiority trial comparing tech-guided vs. human guided (N=233)

Primary Task Support	Program personalisation options
Social Support	Self-Monitoring, Peer-Buddy-System
System Credibility Support	Optimized UX-design regarding data-safety, team, expert
Dialogue Support	Social role, individualized answers, reinforcment

Non-Inferiority:

t1: Cohen's d = 0.04 (95%CI -0.22; 0.30)

t2: Cohen's d = -0.03 (95%CI -0.29; 0.23)

t3: Cohen's d = 0.08 (95%CI -0.18; 0.34)

Mutter et al. BMC Psychology 2023

Mechanisms of Change in Digital Anxiety Interventions
Meta-analytical two-stage structural equation model
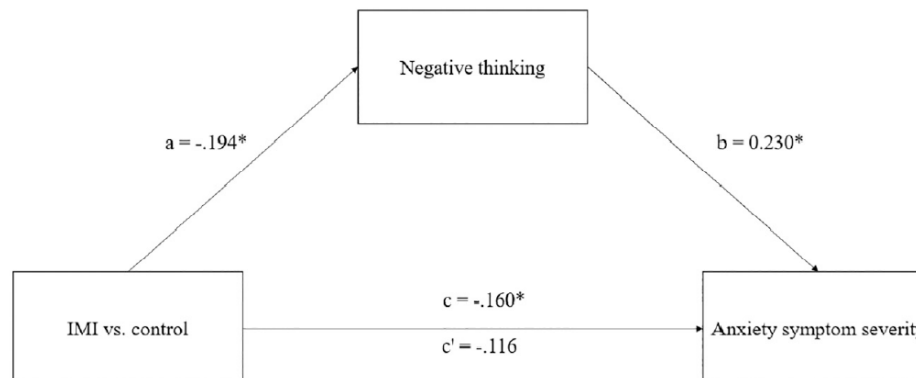
Fig. 2. Path diagram displaying the stage two mediational model of the TSSEM for negative thinking. Values are path coefficients. *Parameter estimates are significantly different from zero (i.e., 95%-CIs do not contain zero).
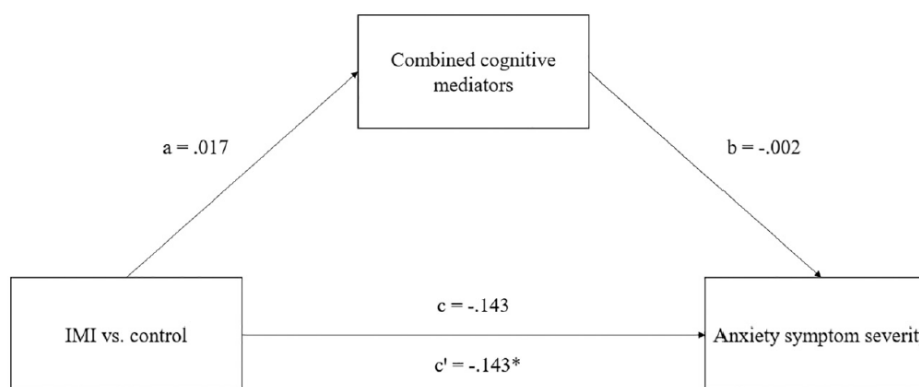
Fig. 3. Path diagram displaying the stage two mediational model of the TSSEM for combined cognitive mediators in clinical samples. Values are path coefficients. *Parameter estimates are significantly different from zero (i.e., 95%-CIs do not contain zero).

Domhardt et al. Clin Psychol Rev 2021b

AI, Precision Mental Health, Personalised Psychotherapy

Montag & Baumeister, 2023; Bendig et al., 2019; Montag et al., 2019; Pryss et al., 2023

From Sensors to Prediction of Health
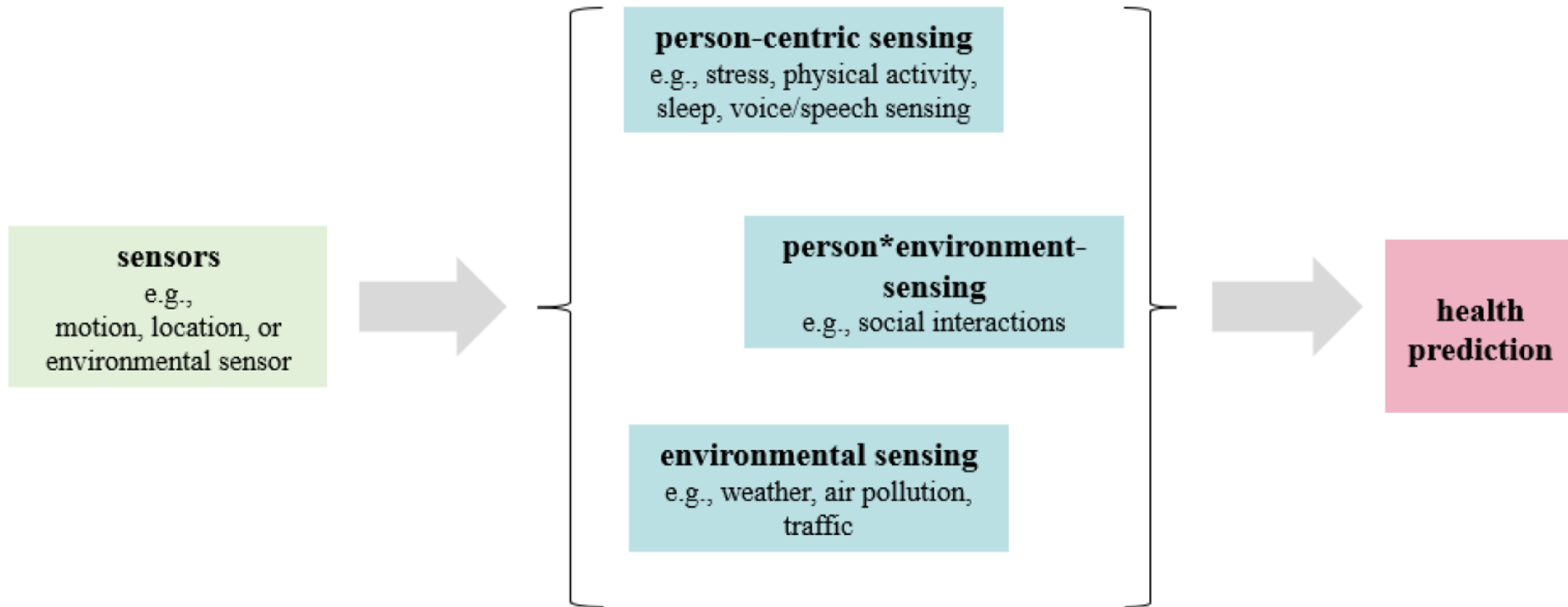
Figure 2. From sensors to prediction of health.

Garatva et al. In Montag & Baumeister Springer, 2023

Digital Phenotyping and Mobile Sensing

Proof-of-Concept Studies

- Depression:

  Variability of visited location (ß -.21), total sleep time (ß .24), time in bed (ß .26)[1]

  Total smartphone usage time (-.019), call duration (-.016)[2]

  Higher use of word categories: I, we, negate, anxiety and eating[3]

  EMA and sensing features best regression model ($R2 = 45.15\%$)[4]

- Anxiety:

  Wake after sleep onset (ß .23), HRV (ß .26)[2]

- Insomnia

  Smartphone usage AUC .57 / .58 (ML Prediction: Random Forest / Naive Bayes)[5]

AWARE-
Smart Sensing

1 Moshe et al. Frontiers Psychiatry 2021; 2 Messner et al. Verhaltenstherapie 2019; 3 Rather et al. Interspeech 2018; 4 Terhorst et al., submitted; 5 Simon et al., submitted; 6 Montag & Baumeister, DPaMS Springer 2023

▶

https://osf.io/5ukt9/
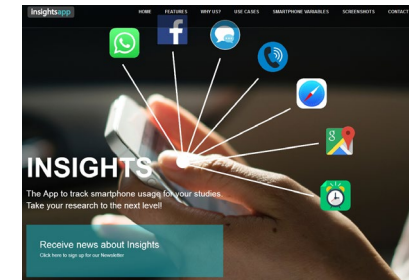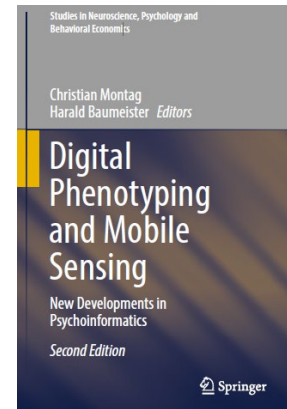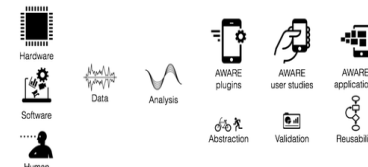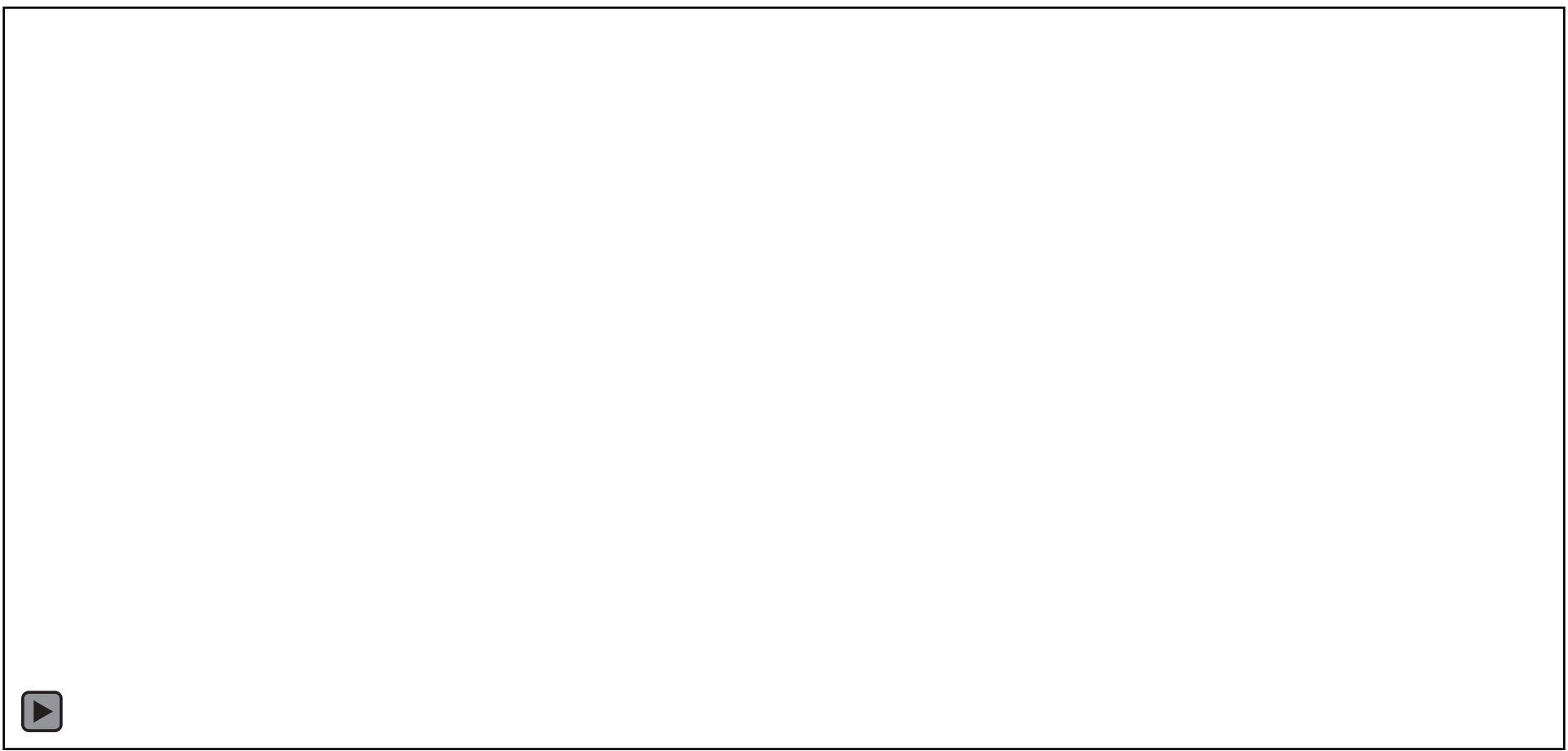
Routine Outcome Monitoring (ROM) Systems

- RehaCAT and SysDok

- Computer-adaptive PROM/PREM testing systems

- Real-world setting implemented („real-world laboraty" approach with > 10.000 patients / year

=> Secondary analysis of clinical routine data
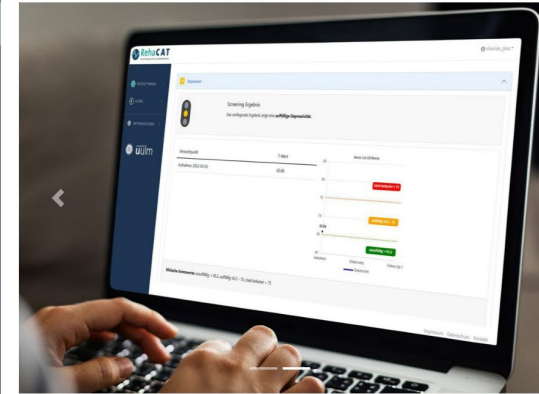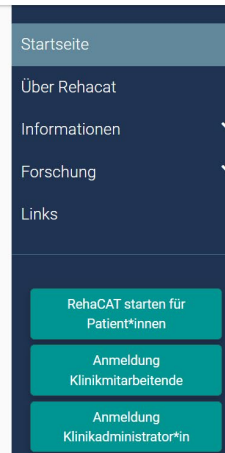
Towards AI-based Clinical Decision Support System (CDSS)

HIS-Data	PROM/PREM/ CAT	EMA / Smart Sensing	Other Data Sources

↓ ↓ ↓ ↓

Data bank

↓ ↓ ↓ ↓

Optimising Diagnostics and Treatment by e.g.:

- Treatment trajectory prediction

- Differential, data-based treatment indication

- Course of treatment prediction with red flag system

- AI-based Interventions (JITAI, Chatbots)

Terhorst et al. in Montag & Baumeister, Springer, 2023
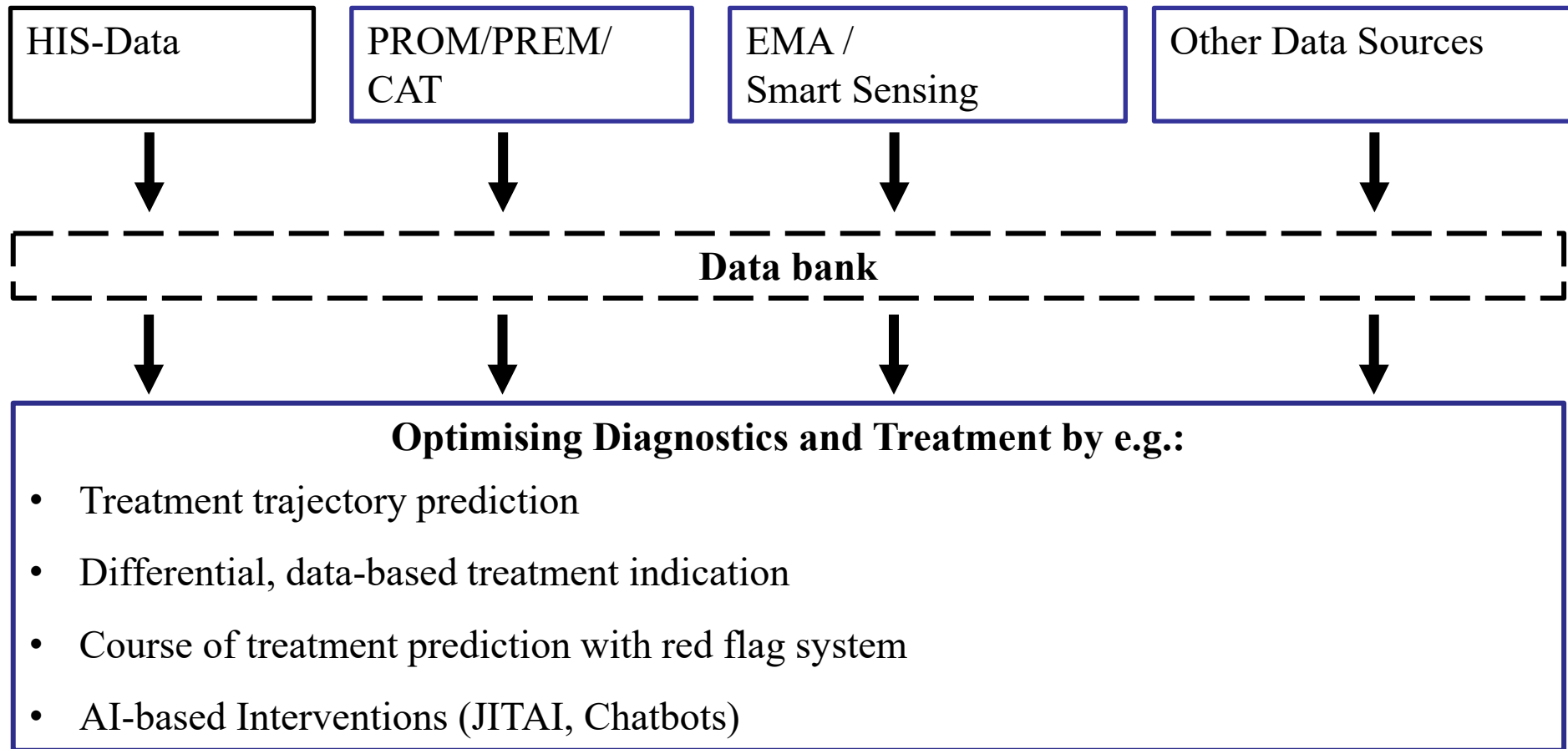
Machine learning optimized use of Depression Screening

- Secondary analysis of RCT with patients with back pain and depression
- 1.030 SCID diagnosis; Screenings: QIDS-16, PHQ-9, HAM-D-17

	AUC of ROC for the best ML	AUC of ROC for sum-score	ΔAUC	95%-CI of the difference	p[a]
QIDS-16—basic[b]	0.935	0.900	0.035	0.02 to 0.05	<0.001
QIDS-16—extended[c]	0.937	0.900	0.036	0.02 to 0.06	<0.001
HAM-D-17	0.876	0.873	0.003	-0.02 to 0.03	0.847
PHQ-9	0.832	0.818	0.014	0.00 to 0.02	0.009

[a] Two-sided bootstrap test for ROC curves within in the testing set, indicating the probability of whether the true difference in AUC is different from 0.

[b] Logistic regression model containing only the QIDS-16 items as features.

[c] Logistic regression model containing QIDS-16 items, the extended feature set (e.g. mean of items), age, and gender.

Terhorst et al. Digital Health 2023

Next Generation Interventions

SISU Chatbot: Chatbot to facilitat mental health well-being
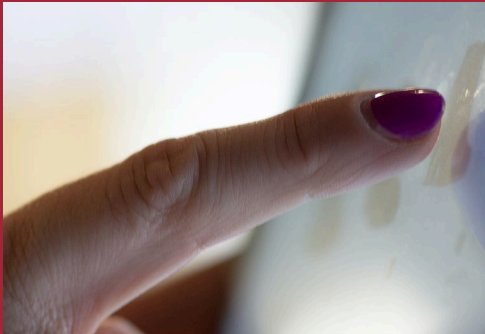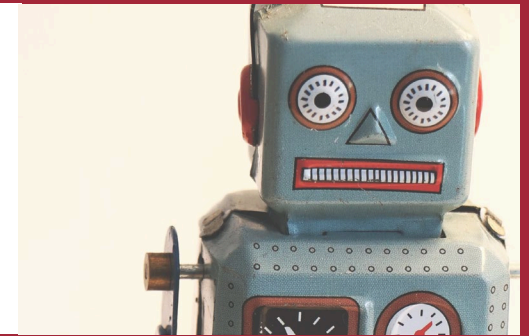
Better Care JITAI: ACTonCANCER augmented by Just-in-time-intervention components using EMA and smart sensing

Just-in-time Intervention

Nahum-Shani et al. Ann Behav Med 2018

Chatbots - Evidence

Figure 4. Forest plot of the 4 studies assessing the effect of using chatbots on the severity of depression.

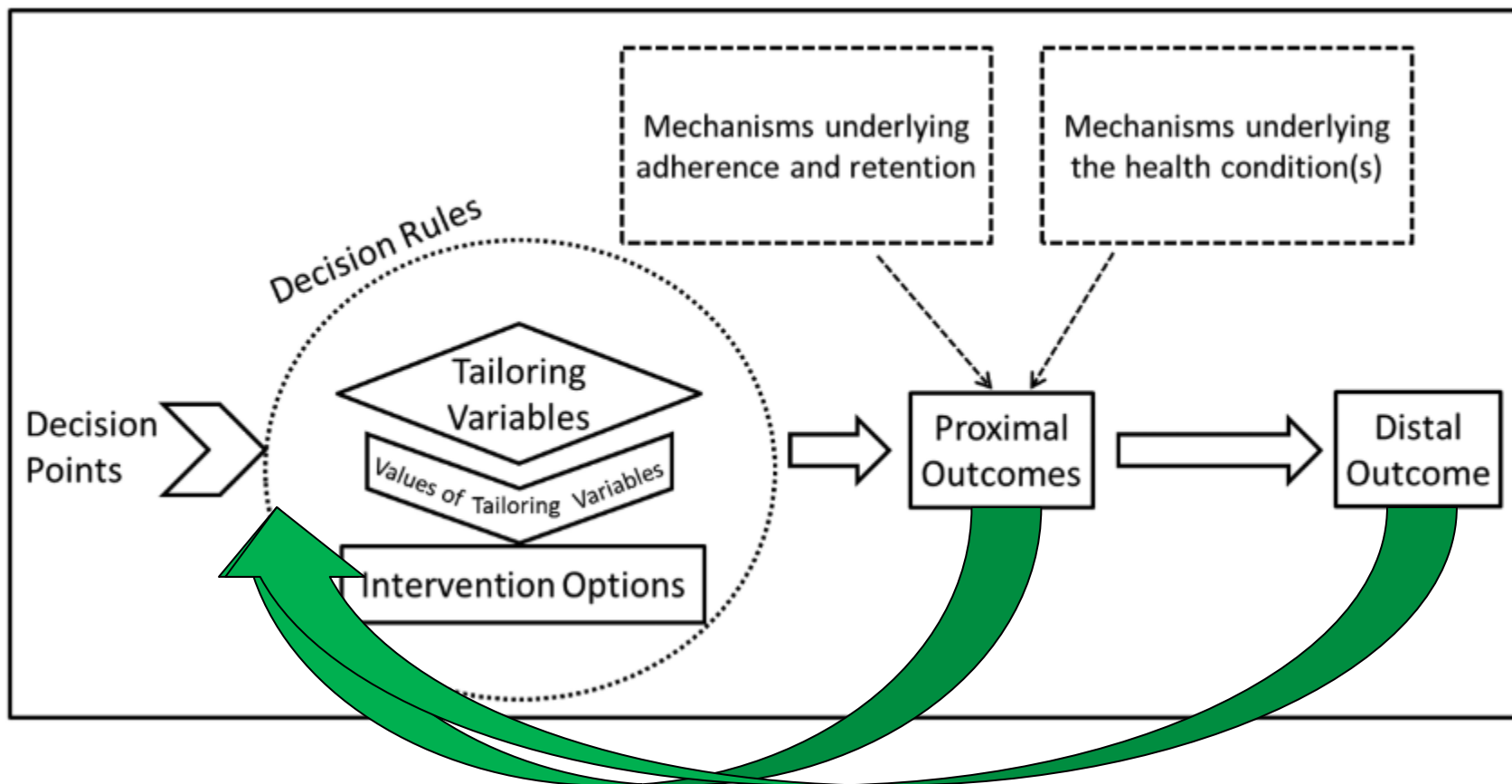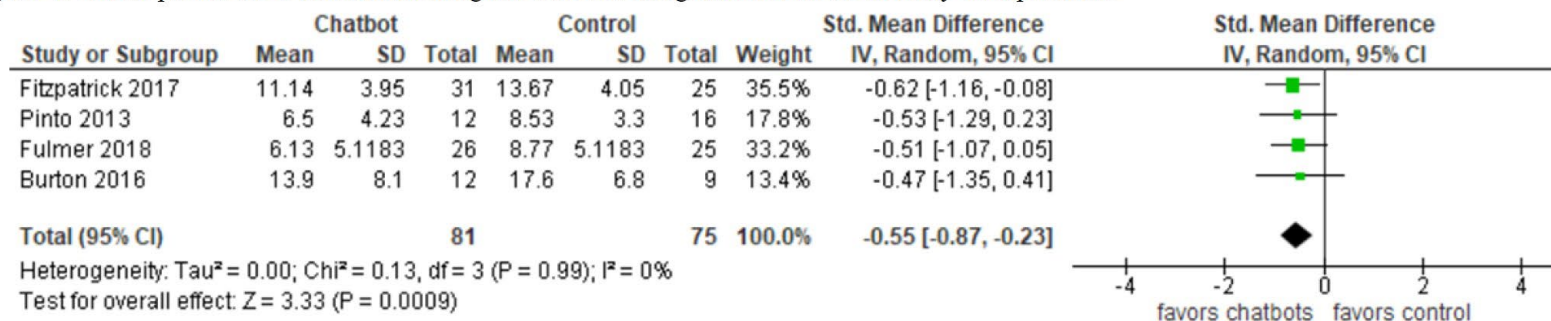| Study or Subgroup	Chatbot Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Fitzpatrick 2017	11.14	3.95	31	13.67	4.05	25	35.5%	-0.62 [-1.16, -0.08]
Pinto 2013	6.5	4.23	12	8.53	3.3	16	17.8%	-0.53 [-1.29, 0.23]
Fulmer 2018	6.13	5.1183	26	8.77	5.1183	25	33.2%	-0.51 [-1.07, 0.05]
Burton 2016	13.9	8.1	12	17.6	6.8	9	13.4%	-0.47 [-1.35, 0.41]
Total (95% CI)			**81**			**75**	**100.0%**	**-0.55 [-0.87, -0.23]**

Heterogeneity: Tau² = 0.00; Chi² = 0.13, df = 3 (P = 0.99); I² = 0%
Test for overall effect: Z = 3.33 (P = 0.0009)

favors chatbots favors control

Figure 5. Forest plot of the 2 studies assessing the effect of using chatbots on the severity of anxiety.

Study or Subgroup	Chatbots Mean	SD	Total	Information Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Fitzpatrick 2017	17.35	3.34	31	16.84	3.35	25	55.4%	0.51 [-1.25, 2.27]
Fulmer 2018	6.13	5.9016	26	9.85	5.9016	25	44.6%	-3.72 [-6.96, -0.48]
Total (95% CI)			**57**			**50**	**100.0%**	**-1.38 [-5.50, 2.74]**

Heterogeneity: Tau² = 7.18; Chi² = 5.05, df = 1 (P = 0.02); I² = 80%
Test for overall effect: Z = 0.66 (P = 0.51)

favors chatbot favors information

Abd-Alrazaq et al. JMIR 2020

Speech-based Chatbots

Table 1. Overview and characteristics of included records.

Reference, publication year	Study aim	Type of study participants	Addressed medical condition	Voice-enabled device type	Intervention category
Amith et al (2019) [59]	Development and acceptance evaluation	Healthy adults with at least one child under the age of 18 years (n=16)	Cancers associated with HPV[a]	Tablet	Support
Amith et al (2020) [60]	Development and acceptance evaluation	Healthy young adults aged between 18 and 26 years (n=24)	Cancers associated with HPV	Tablet	Support
Boyd and Wilson (2018) [61]	Criterion-based performance evaluation of commercial conversational agent	Authors as raters (n=2)	Cancers associated with smoking	Smartphone	Support
Cheng et al (2019) [62]	Development and acceptance evaluation	Older adults (n=10)	Diabetes (type 2)	Smart speaker	Monitoring and support
Galescu et al (2009) [63]	Development and performance evaluation	Chronic heart failure patients (n=14)	Heart failure	Not specified	Monitoring
Greuter and Balandin (2019) [64]	Development and performance evaluation	Adults with lifelong intellectual disability (n=9)	Intellectual disability	Smart speaker	Support
Ireland et al (2016) [65]	Development and acceptance evaluation	Adults recruited on campus (n=33)	Parkinson disease, dementia, and autism	Smartphone	Monitoring
Kadariya et al (2019) [66]	Development and acceptance evaluation	Clinicians and researchers (n=16)	Asthma	Smartphone	Monitoring and support
Lobo et al (2017) [67]	Development and acceptance evaluation	Healthy adults working regularly with senior patients (n=11)	Heart failure	Smartphone	Monitoring and support
Ooster et al (2019) [68]	Development and performance evaluation	Normal hearing (n=6)	Hearing impairment	Smart speaker	Monitoring
Rehman et al (2020) [69]	Development and performance and acceptance evaluation	Adults affiliated with the university (n=33)	Diabetes (type 1, type 2, gestational) and glaucoma	Smartphone	Monitoring and support
Reis et al (2018) [70]	Criterion-based performance evaluation of a commercial conversational agent	Not specified (n=Not specified)	Depression	Not specified	Support

[a]HPV: human papillomavirus.

Bérubé et al. JMIR 2021

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram of included studies.
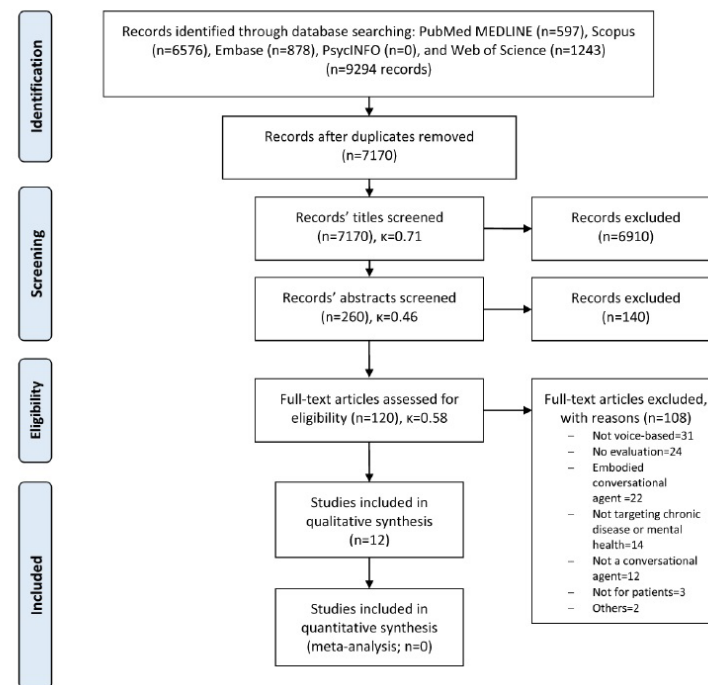
Dissemination and Implementation

DISSEMINATION

Imagine there are effective digital

interventions and nobody knows about

them

ACCEPTANCE - UPTAKE - ADHERENCE

Imagine there are effective

interventions and nobody cares to

use them

Blended Therapy: PSYCHOnlineTHERAPY

PSYCHOnlineTHERAPY

**as blended therapy approach
for outpatient psychotherapy**

**Funded by Innovationsausschuss
(GBA)**

Website:
➔ https://www.psychonlinetherapie.de

eSano Online-Intervention:
PSYCHOnlineTHERAPY
Examined for Depression and Anxiety
Realised for ICD-10 F1-F6

Social Media:
Facebook/Instagram
@psychonlinetherapie

Twitter
@psychONtherapie

Example Stand-Alone: StudiCare

„StudiCare" **as part of WHO-WMH-International College Student Initiative**

In Germany a collaborative project of UULM and TUM

Website:
➔ https://www.studicare.com

StudiCare as Landingpage and „virtual health care centre"

WHO WMH ICS Initiative

> 20 (ongoing) RCTs

500.000+ students

20 participating universities

> 16 interventions

Longitudinal Survey

Reaching those we usually do not reach? Habicht et al. Nature Medicine 2024

- Naturalistic, retrospective study with N = 129.400 NHS patients asking for talking therapy

- 15% referal increase with implemented chatbot compared to 6% in matched controls

- Increase most pronouced in minorities (non-binary, ethnic minorities)

- Note: Exploratory study yet to be confirmed
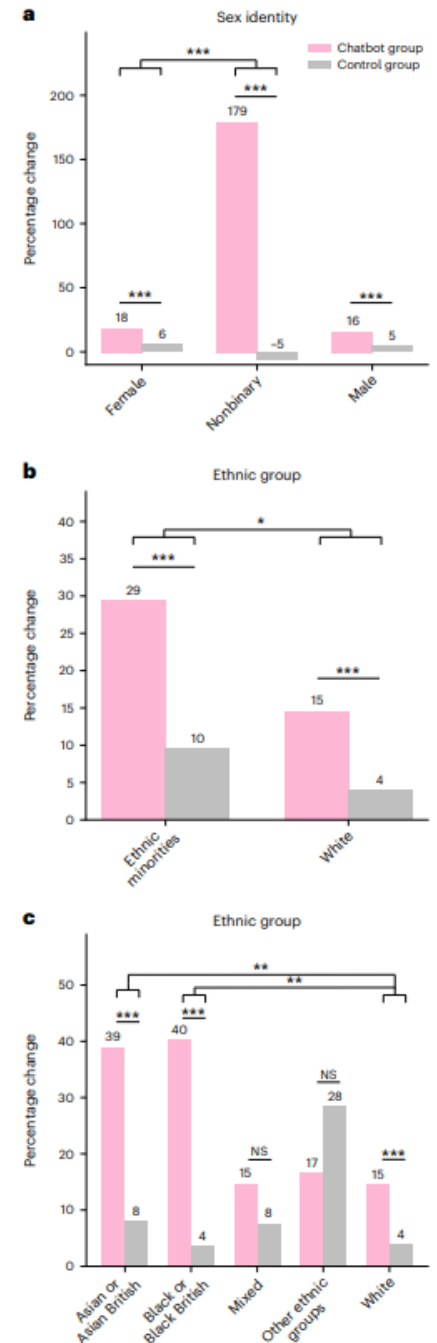
IMPROVA: EU-project on mental health promotion in the school setting

IMPROVA

ABOUT THE PROJECT   WHO'S INVOLVED   NEWS   CONTACT

IMPROVA

BOOSTING TEEN MENTAL HEALTH IN EUROPE AND BEYOND

Supported by Horizon Europe, the IMPROVA programme will test and evaluate the adoption of an eHealth platform focused on promoting mental health and early-detecting mental health issues in secondary schools across Europe. IMPROVA empowers adolescents and families to make better decisions regarding their mental health and provides schools and the community with tools to achieve a society with better mental health and lower stigma.

About the project

German Centre for
Mental Health
Child and Adolescent Health

- Digital Mental Health Infrastructure
- armonising assessments and data management
- Repository on EMA, Smart Sensing, digital diagnostics and interventions
- Information, diagnostics and intervention platform for children and adolescents with obesity

=> Overcoming the translation gap from bench to patient care

Personalising and Scaling Up Digital Mental Health Care and Research

1. Moderator-Mediator Research: Illuminating the Black Box of Psycho-Social Health Interventions

2. AI-based Personalisation (Smart Sensing / JITAI / Chatbot / CDSS)

3. Scaling Up Research: „Real-Word Laboratory" Approach

Many thanks for your Attention

…and thanks to my team!
…and to all collaborators, participants and funding agencies!