

Challenges and opportunities for theorizing and implementing inquiry-based learning



van der Graaf et al.

Covic

Agesilaou & Kyza

Flegr & Kuhn

*What can we learn looking at these studies **in tandem**?*

First of all, I would like to thank the symposium organizers and presenters; the contributions provide an excellent overview of current approaches in IBL research and a strong basis for discussing where the field is standing and going next.



Real experiments & virtual reality experiments

IBL design to support privacy data literacy

van der Graaf et al.

Flegr & Kuhn

Covic

Agesilaou & Kyza

Teachers' knowledge and attitudes

Teachers' attitudes and intentions



Who can deliver the package?

Who wants to deliver the package?

Which package to deliver first?

What should the package contain?

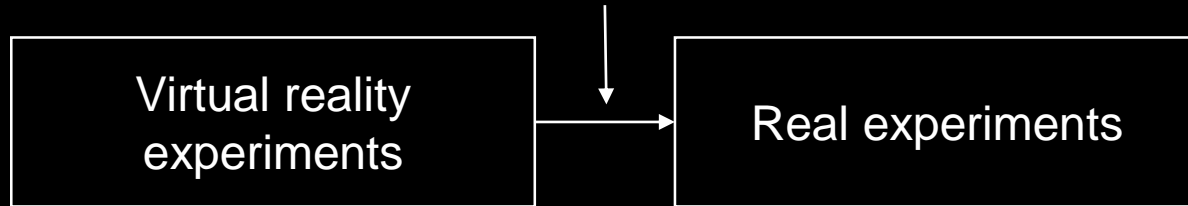
Should it always be inquiry-based learning?



*How can we **replace** or **combine** the **IBL** package with other pedagogies to optimize learning and gather new insights about the studies' questions?*

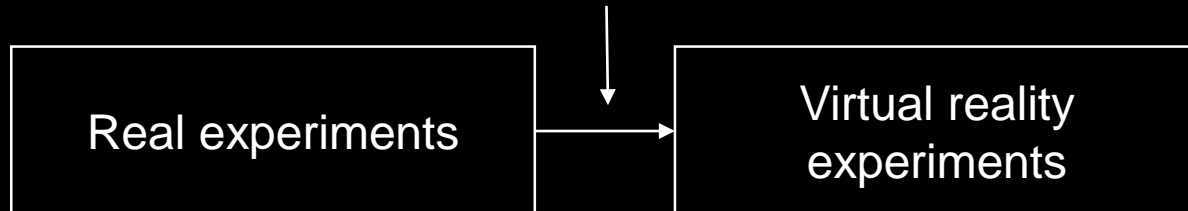
Composite instructional design
Loibl et a. (2024)

Intermediate knowledge



How and why should virtual and real experiments affect each other?

Intermediate knowledge



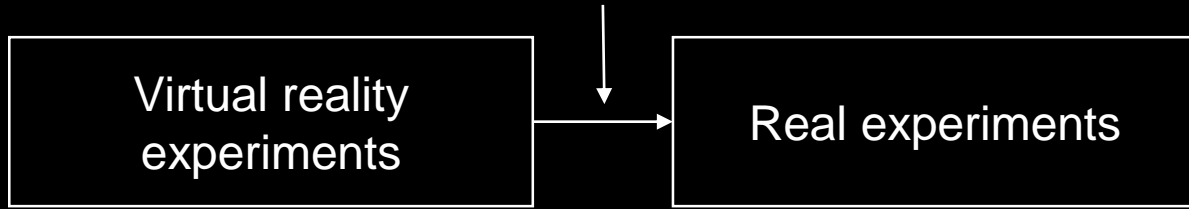
Real experiments & virtual reality experiments

Flegr & Kuhn



Which package to deliver first?

Intermediate knowledge



Procedural knowledge about using the virtual platform

Conceptual knowledge about the domain

Conceptual knowledge about the context

Conceptual knowledge about the virtual representations

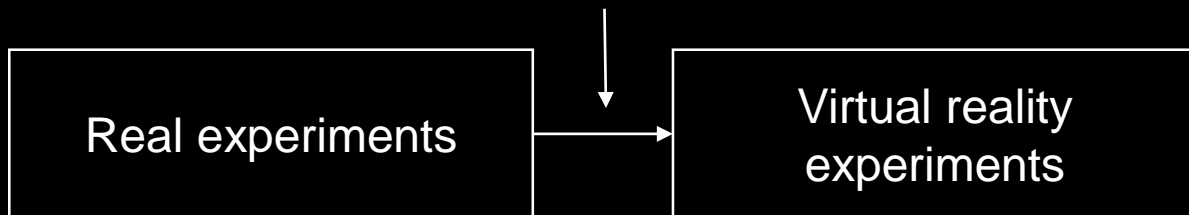
Procedural knowledge about conducting the experiments

Conceptual knowledge about the domain

Conceptual knowledge about the context

Conceptual knowledge about the analog representations

Intermediate knowledge



Real experiments

Virtual reality experiments

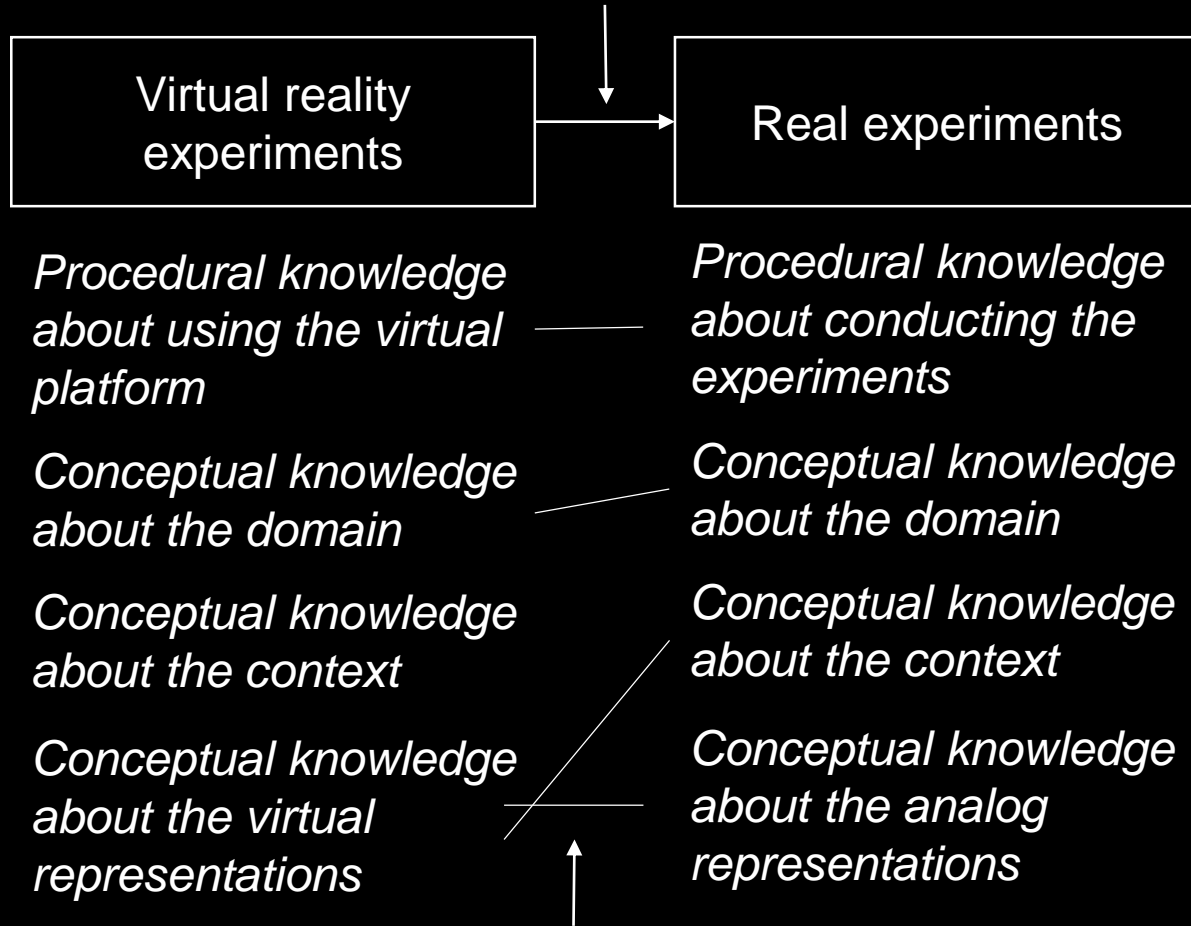
Real experiments & virtual reality experiments

Flegr & Kuhn



Which package to deliver first?

Intermediate knowledge



Linking processes to build up generalized knowledge structures

- Compare and contrast
- Expansive framing
- Building on activated CK (& gap awareness)

Edelsbrunner et al. (2024); Linn (2004); Loibl et al. (2024); Schumacher & Stern (2022);

Real experiments & virtual reality experiments

Flegr & Kuhn

Package Knowledge integration



Which package to deliver first?

van der Graaf et al.

Teachers' knowledge and attitudes



Who can deliver the package? Covic

Teachers' attitudes and intentions



Who wants to deliver the package?

Re-conceptualizing IBL as a curricular element of multi-phase instruction

Covic:

„Only“ monthly or weekly use of E-IBL -> is this really so little?

*We should consider **quality instead of quantity***

Active learning approaches such as IBL are ~~good~~ *bad* need to be carefully orchestrated in the instructional process (ICAP; Chi & Wiley, 2014; Loibl et al., 2024)

van der Graaf et al.: Let's measure more!

- Teachers' intentions to consider use IBL as part of their learning sequences
- Teachers' competencies and experiences in implementing IBL as part of an instructional sequence
- ~~IBL/research center~~ -> Instructional alignment and orchestration center

*Such a **beautiful** two-study conjecture mapping-design approach!*

Should the contents of the package be the same for everyone?

- Agesilaou & Kyza: Scaffolding
- How about **removing IBL** for some of the learners or phases?
- Adaptive teaching on the level of packages, not only package contents
- Self-regulated learning materials
- Direct instruction starting with computer-based materials
- Gamification **not for everyone**
- **Flexible** Think-pair-share phases

IBL design to support **privacy data literacy**

Agesilaou & Kyza



What should the package contain?

***When and why** should we use inquiry-based learning, and how should we **combine** it with other approaches and ensure that this combination supports learning?*



*What do **you** think about the contributions and where IBL research should go next?*

Challenges and opportunities for theorizing and implementing inquiry-based learning

*What can we learn from the **common methodology and issues** of these studies?*

Challenges and opportunities for theorizing and implementing inquiry-based learning

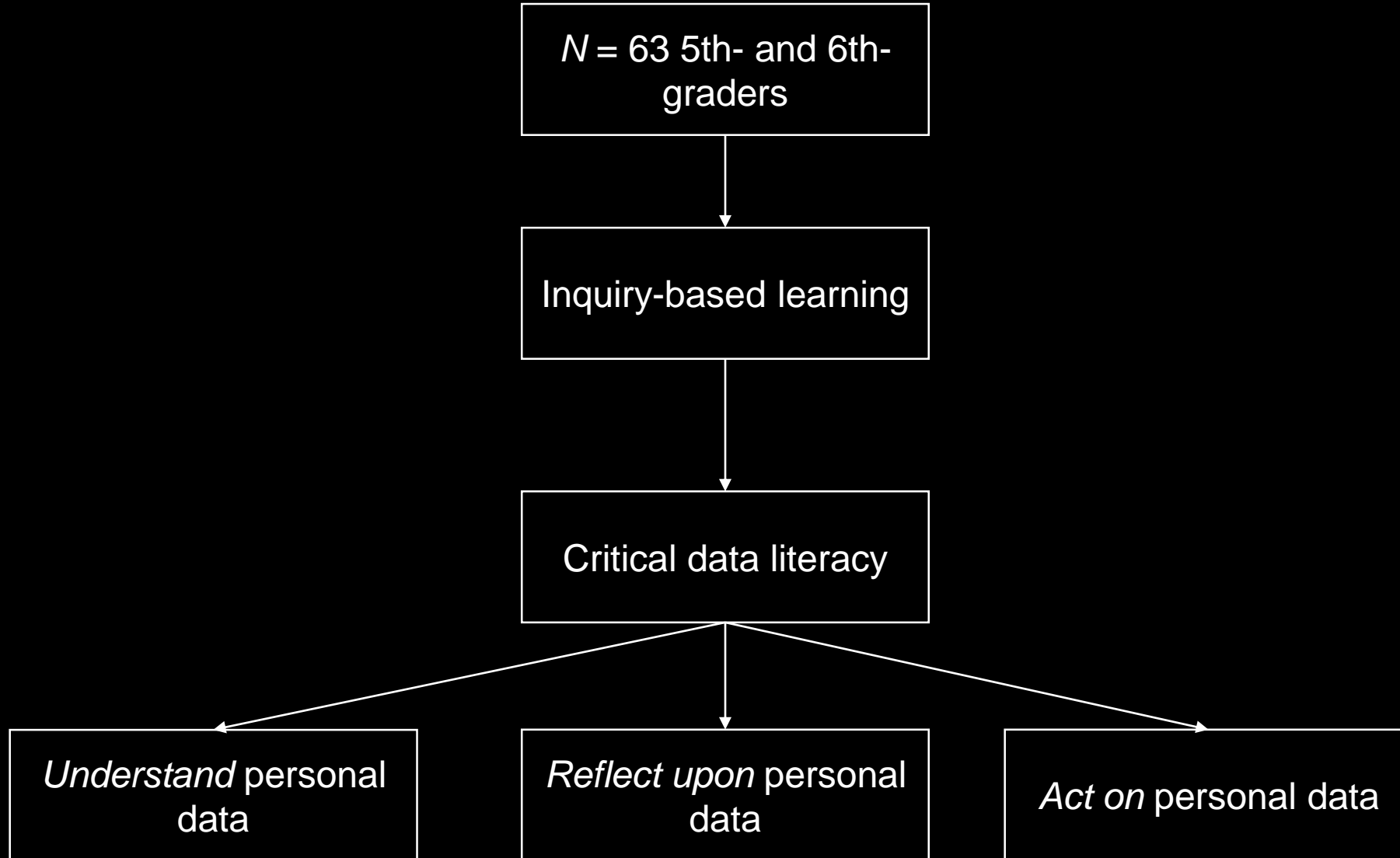
Orchestration:

Agesilaou & Kyza: What about going a step back and asking not within the framework of IBL: How can we best design tasks and scaffold? But: For whom is IBL best, and in what amount?

Flegr and Kuhn: Sequences and orchestrations. Katharina Loibl – framework :)

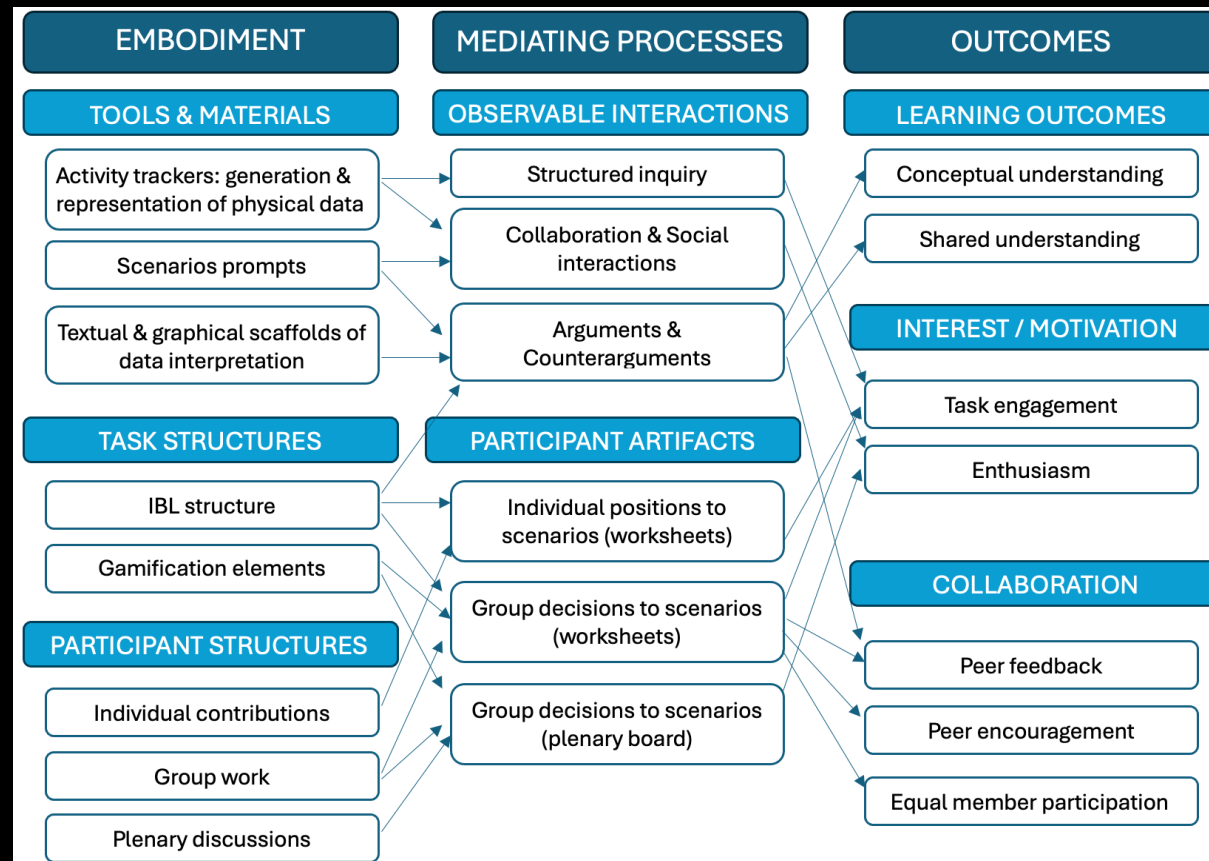
Covic: Is it good that teachers use IBL often? Monthly to weekly does not seem so little to me. Depending on the learning goal:

Agesilaou & Kyza



Agesilaou & Kyza

Conjecture map



Agesilaou & Kyza

My naïve methodologist's view:

Sampling error and variability

*Design adaptations based on qualitative case study 1:
Novelty effects – will they hold across samples/populations of learners?*

*-> Adaptive learning environment:
Adapt not only the scaffolds, but the design*

Let's adapt the (very) pedagogy!

e.g.,

Maybe even the focus in IBL/group discussion?

-> Some learners would benefit from more “think”

Flegr & Kuhn

Learning with multiple representations:

Analog representation (Real Experiment)

Digital representation (Virtual Reality Experiment)

Key question:

What are the processes allowing a benefit?

My suggestion:

Integration processes

-> These need to be supported!

My assumption:

The real experiment is easier to digest when it comes second – higher extraneous cognitive load. When I have built up prior knowledge, the intrinsic and germane load may be lower -> I can concentrate more on handling the extraneous factors

Covic

*Teachers`attitudes & beliefs
about E-IBL, self-perceived ped.
Competences, contextual
factors (school provisions etc.)*

*N = 1061 teachers –
representative? 99,2% female.
Age?*

Van der Graaf et al.

*„Low reliability“ of the content
knowledge test: Really? I don't
think so!.*

*Latent profile analysis:
Focus on AIC?*

https://bit.ly/PeterE_presentations



<https://link.springer.com/article/10.3758/s13428-025-02706-2>



An Experimental Comparison of the Seven-Point- and Visual Analogue Scale in Intensive Assessment

Behavior Research Methods (2025) 57:217
<https://doi.org/10.3758/s13428-025-02706-2>

ORIGINAL MANUSCRIPT



Comparing Likert and visual analogue scales in ecological momentary assessment

Jonas M. B. Haslbeck^{1,2} · Alberto Jover Martínez² · Anne J. Roefs² · Eiko I. Fried³ · Lotte H. J. M. Lemmens² ·
Esmee Groot² · Peter A. Edelsbrunner^{4,5}

Accepted: 19 April 2025 / Published online: 2 July 2025
© The Author(s) 2025

Within-person perspective

Blume et al., 2022; Blume & Schmiedek, 2024

Idiography ~~vs.~~ & nomothetics
Molenaar & Valsiner, 2009

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

Not at all Extremely

Tap on the line to start!

Control of trait variation
Hamaker et al., 2007

Assessment of dynamics
Haslbeck & Ryan, 2022

Methodology: Commonly unjustified/intuitive
Haslbeck et al., 2023

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

Not at all Extremely

Tap on the line to start!

Typical approach:
7-step Likert or visual analogue scale,
linear mixed model or ML-SEM
Haslbeck et al., 2023

**Earlier studies: Mainly cross-sectional,
increased reliability with > 4 response
categories** (see Simms et al., 2019; Fritz et al., 2024)

Research question:
How does the response scale affect...
1) Univariate statistics/distributions
2) Multivariate statistics/distributions
3) Relations with external covariates
4) Subjective ratings

Often studied

Often used

Often studied



Context: Emotions, single items, university students (few clin. diagnoses)

Positive (happy, satisfied,..., 5 items) and negative (stressed, worried,... 9 items)
valence

7-step response scale vs. visual analogue scale (101-step)

As far as possible parallel (e.g., only endlables for 7-step scale)

App limitations:

7-step vertical, VAS horizontal

7-step = not at all, 2, 3, 4, 5, 6, extremely

Between-person (avoiding carry-over effects/reactance):

Two weeks, 3x daily, either always 7-step or VAS

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

☐ Not at all

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

☐ Extremely

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

Not at all Extremely

Tap on the line to start!

$n(\text{Likert}) = 63$

$n(\text{VAS}) = 56$

$M(\text{age}) = 22$ ($SD = 4$)

Models:

Bayesian multilevel modeling in brms

0-1 normalization

Inter-individual distributions of descriptive statistics per person:

e.g. within-person means: Zero-one inflated beta

Fixed effects:

Response format (contrast coding, baseline = Likert),
valence (effects coding) + interaction

Random effects:

Intercept across persons, slopes across items

Full distributional models:

Fixed effects on all distributional parameters (zero- & one-shares, both beta-parameters)

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

☐ Not at all

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

☐ Extremely

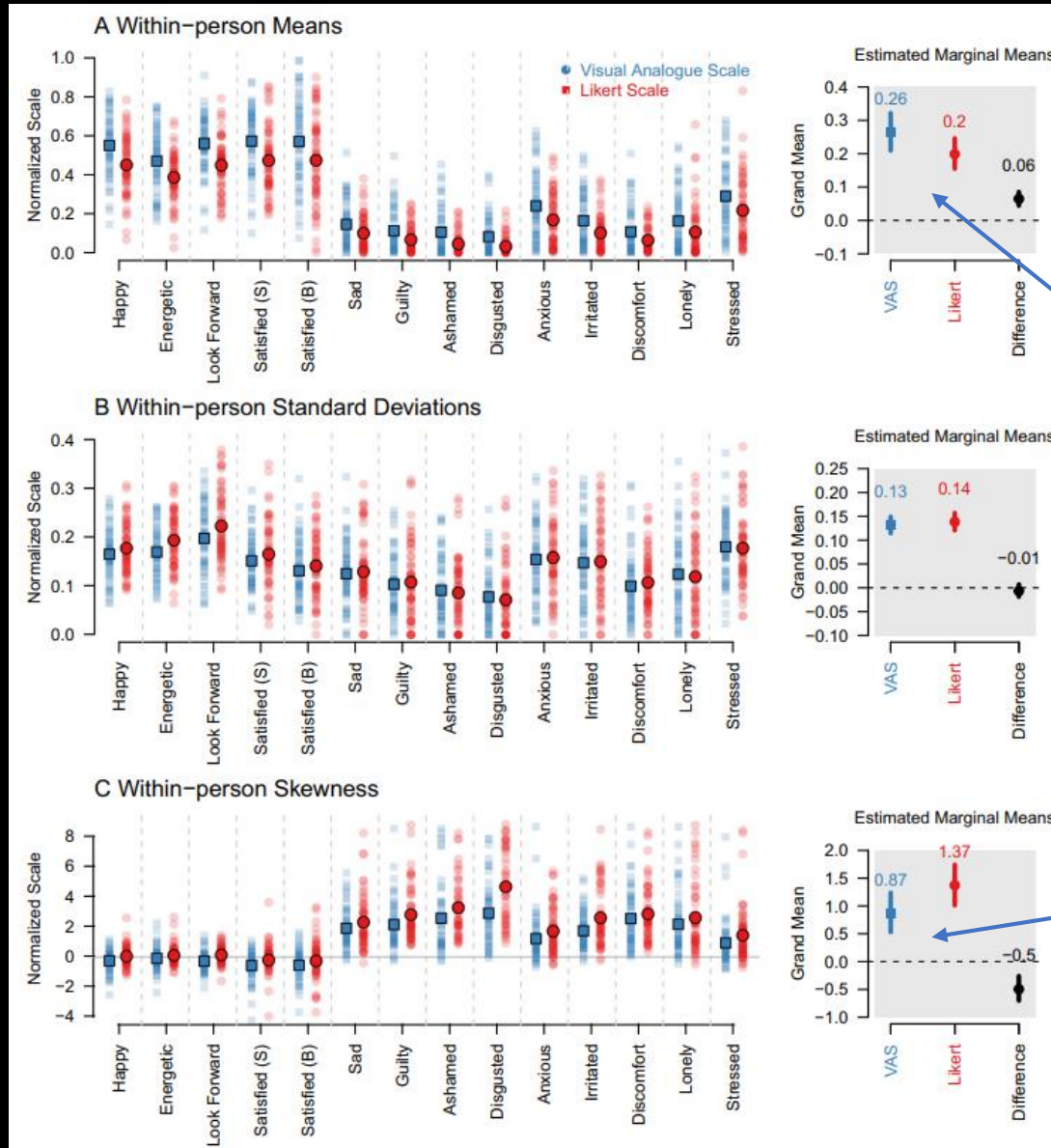
Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

Not at all Extremely

Tap on the line to start!

Results: Descriptive distributional parameters



7-step

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

☐ Not at all

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

☐ Extremely

VAS

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

Not at all

Extremely

Tap on the line to start!

Higher means

Lower skewnesses

Results: Descriptive distributional parameters

7-step

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

Not at all

2

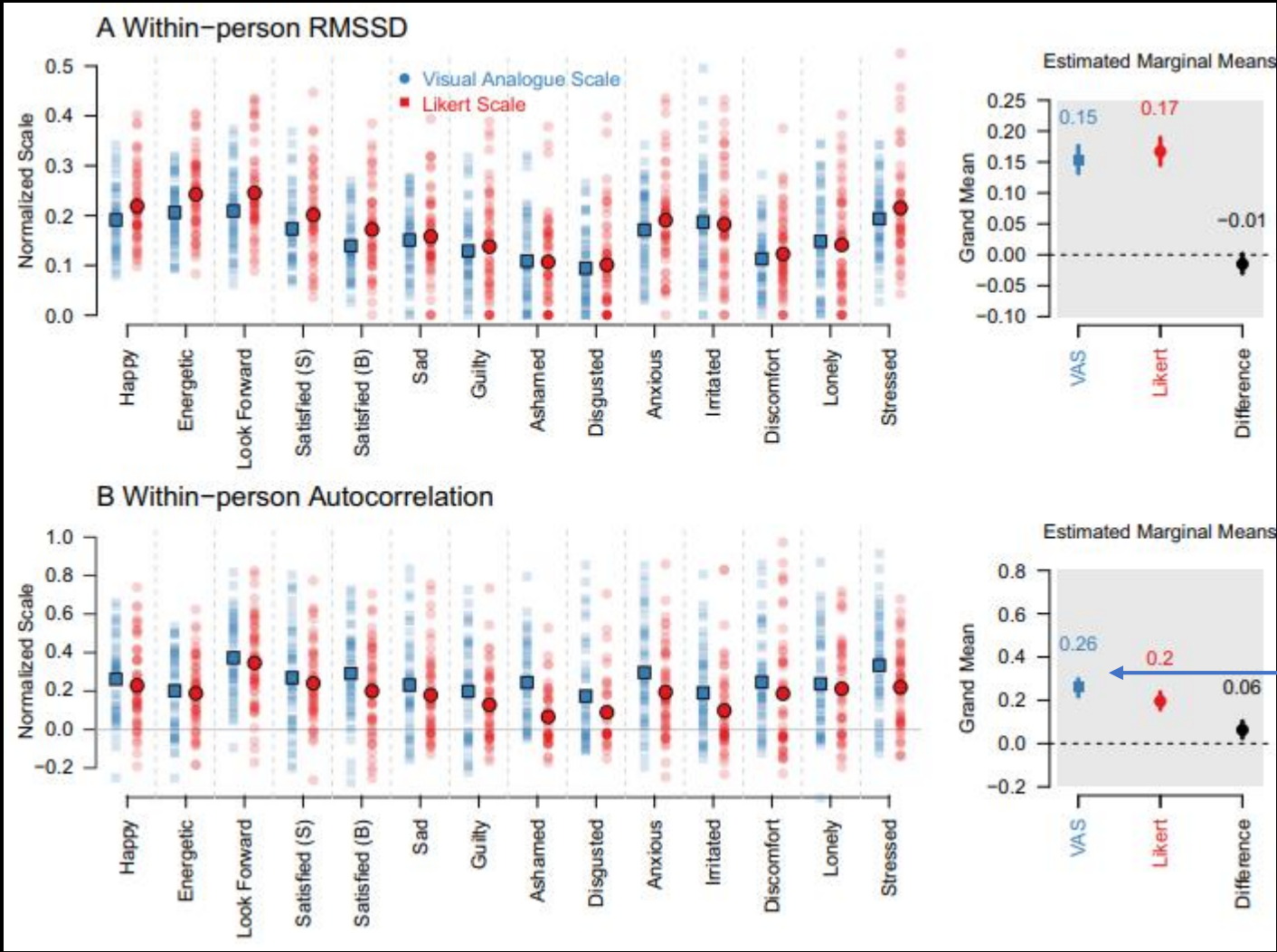
3

4

5

6

Extremely



VAS

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

Not at all

Extremely

Tap on the line to start!

Higher autocorrelations

Results: Descriptive multivariate parameters

7-step

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

☐ Not at all

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

☐ Extremely

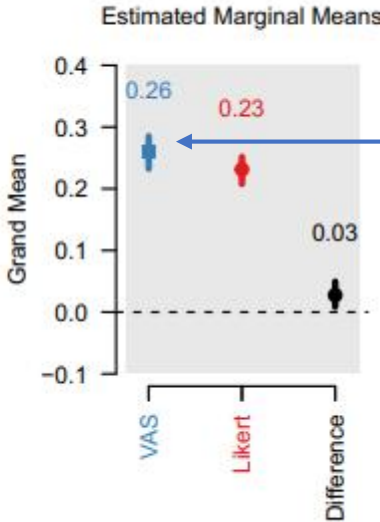
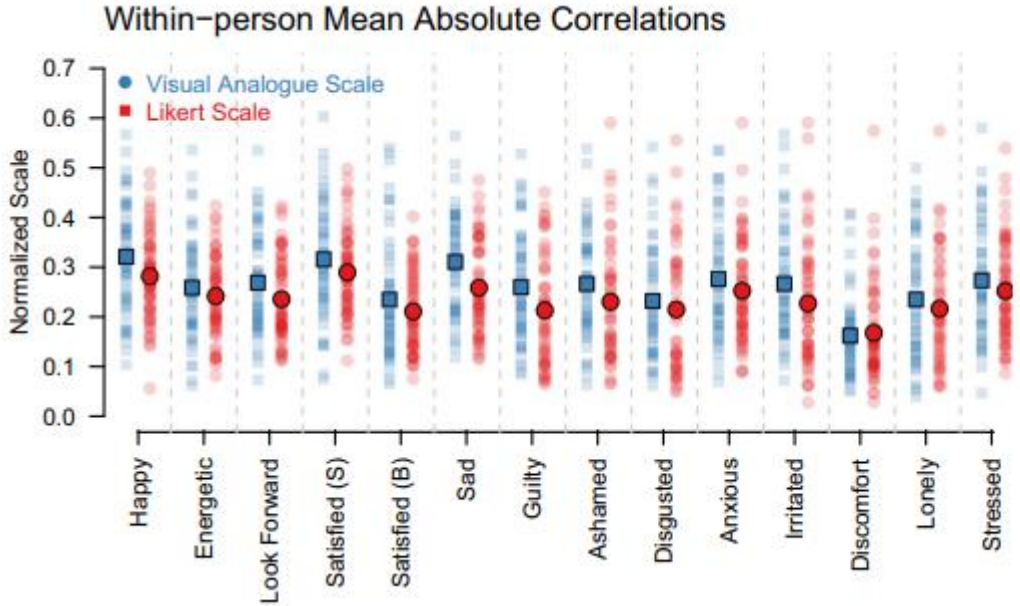
VAS

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

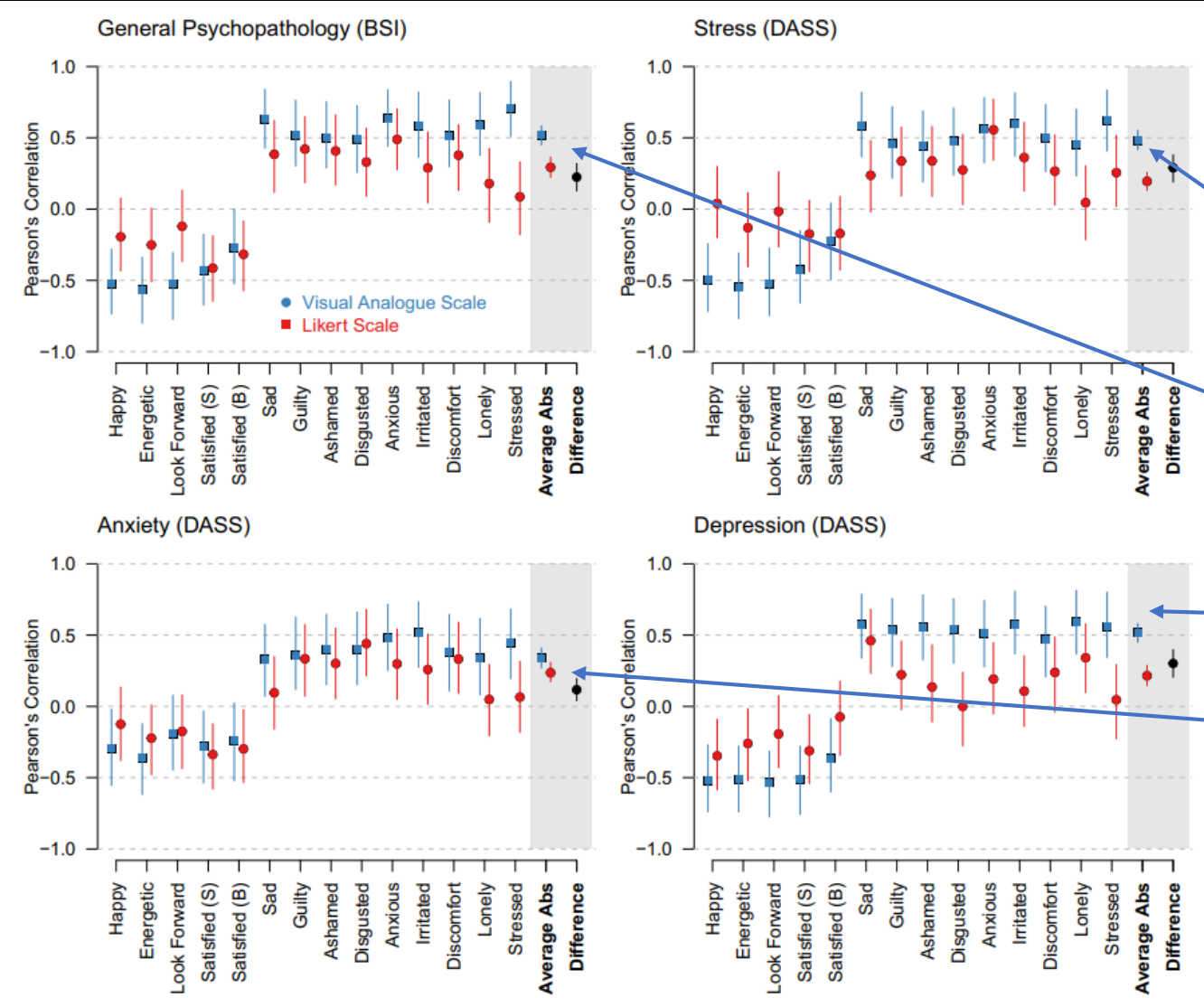
Not at all Extremely

Tap on the line to start!



Slightly stronger within-person item correlations

Results: Correlations with external criteria: General psychopathology and depression/anxiety/stress



7-step

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

☐ Not at all

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

☐ Extremely

VAS

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

Not at all

Extremely

Tap on the line to start!

Brutally stronger correlations

Results: Self-reports

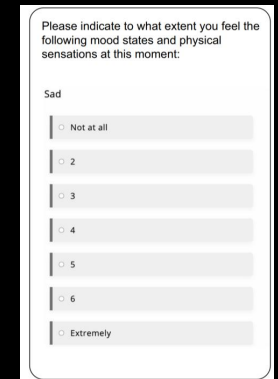
Subjective ratings quite similar; descriptively, VAS slightly more exhausting and confusing

Little multimodality on both scales (Haslbeck et al., 2023)

Missing data and response times similar

No *initial elevation bias* (Shrout et al., 2018)

7-step



Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

☐ Not at all

☐ 2

☐ 3

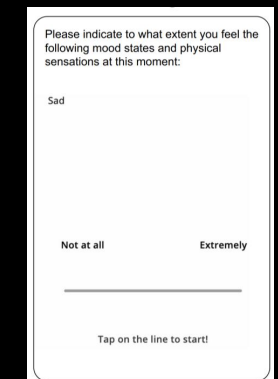
☐ 4

☐ 5

☐ 6

☐ Extremely

VAS



Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

Not at all Extremely

Tap on the line to start!

Results: Interpretations

- Our VAS captures more systematic variation close to the scale minimum (Higher means, lower skewness, higher correlations with external criteria) – preliminary support for VAS in similar studies and populations

Limitations:

- 7-step scale: Second category „1“ instead of „2“?
- Labels (e.g., mildly/very little)
- We need replications and factorial study designs (number response options, label positions & contents, horizontal vs. vertical, initial slider point on VAS) randomize at once (Baribault et al., 2018), potentially within-person
- We also need cognitive surveys and formal models (explore & model the latent response process)
- Multi-item scales

7-step

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

☐ Not at all

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

☐ Extremely

VAS

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

Not at all Extremely

Tap on the line to start!

https://bit.ly/PeterE_presentations



<https://link.springer.com/article/10.3758/s13428-025-02706-2>



Baribault, B., Donkin, C., Little, D. R., Trueblood, J. S., Oravecz, Z., van Ravenzwaaij, D., White, C. N., De Boeck, P., & Vandekerckhove, J. (2018). Metastudies for robust tests of theory. *Proceedings of the National Academy of Sciences*, 115(11), 2607–2612.

<https://doi.org/10.1073/pnas.1708285114>

Blume, F., Irmer, A., Dirk, J., & Schmiedek, F. (2022). Day-to-day variation in students' academic success: The role of self-regulation, working memory, and achievement goals. *Developmental Science*, 25(6), e13301. <https://doi.org/10.1111/desc.13301>

Blume, F., & Schmiedek, F. (2024). It counts in every single lesson: Between-and within-person associations of teaching quality and student self-regulation. *Learning and Instruction*, 92, 101908.

Fritz, J., Piccirillo, M. L., Cohen, Z. D., Frumkin, M., Kirtley, O., Moeller, J., Neubauer, A. B., Norris, L. A., Schuurman, N. K., Snippe, E., & Bringmann, L. F. (2024). So You Want to Do ESM? 10 Essential Topics for Implementing the Experience-Sampling Method. *Advances in Methods and Practices in Psychological Science*, 7(3), 25152459241267912. <https://doi.org/10.1177/25152459241267912>

Hamaker, E. L., Nesselroade, J. R., & Molenaar, P. C. (2007). The integrated trait–state model. *Journal of research in personality*, 41(2), 295–315. Haslbeck, J. M. B., & Ryan, O. (2022). Recovering Within-Person Dynamics from Psychological Time Series. *Multivariate Behavioral Research*, 57(5), 735–766. <https://doi.org/10.1080/00273171.2021.1896353>

Haslbeck, J., Ryan, O., & Dablander, F. (2023). Multimodality and skewness in emotion time series. *Emotion*. <https://psycnet.apa.org/record/2023-72233-001>

Molenaar, P. C., & Valsiner, J. (2009). How generalization works through the single case: A simple idiographic process analysis of an individual psychotherapy. *YIS: Yearbook of idiographic science*, 1, 23–38.

Shrout, P. E., Stadler, G., Lane, S. P., McClure, M. J., Jackson, G. L., Clavé, F. D., Iida, M., Gleason, M. E. J., Xu, J. H., & Bolger, N. (2018). Initial elevation bias in subjective reports. *Proceedings of the National Academy of Sciences*, 115(1), E15–E23. <https://doi.org/10.1073/pnas.1712277115>

Simms, L. J., Zelazny, K., Williams, T. F., & Bernstein, L. (2019). Does the number of response options matter? Psychometric perspectives using personality questionnaire data. *Psychological Assessment*, 31(4), 557–566. <https://doi.org/10.1037/pas0000648>

7-step

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

☐ Not at all

☐ 2

☐ 3

☐ 4

☐ 5

☐ 6

☐ Extremely

VAS

Please indicate to what extent you feel the following mood states and physical sensations at this moment:

Sad

Not at all Extremely

Tap on the line to start!