Experimental manipulation „in the wild“: Proposing a within-person encouragement design

Seminar 5: Diaries and intensive longitudinal data in intervention designs
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Overview

Within-person couplings of different variables can differ from between-person correlations and across individuals → individual causal effects & basis for individualized interventions?

Within-person experimental designs

Within-person encouragement design

Between-person encouragement designs

Multilevel Models

Instrumental variable estimation
Children differ in couplings of variables across time

Child 1

$\text{Task-Related Joy}$

$\text{Working Memory Performance}$

$r = .33$

Child 2

$r = .56$

$r = -.01$

$r = .56$

$r = .33$

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Children differ in couplings of variables across time

$\text{Task-Related Joy}$

$\text{Working Memory Performance}$

$\text{Child 1}$

$r = .33$

$\text{Child 2}$

$r = -.01$

$r = .56$
Background: Within-person experiments

Single-case studies with ABAB designs

→ Typically compare longer baseline & intervention phases

→ Call for more use of randomization in single-case designs

(Kratochwill & Levin, 2010; Psychological Methods)
Background: Within-person experiments

Within-person experimentation at day-level

Self-experimentation as a source of new ideas: Ten examples about sleep, mood, health, and weight

→ Appropriate for treatments that have immediate and short-lived effects

Roberts (2004; BBS)
Problem: Strict manipulation often impossible in daily life

Practical constraints:
   e.g., duties that prohibit execution of treatment behavior

Ethical constraints:
   e.g., keeping people from showing a desired behavior

Possible solution:
Randomly distributed *encouragement* to show behavior
Background: Encouragement designs

When strict randomization into treatment is not possible due to ethical/practical issues:
→ Randomization into encouragements conditions
→ Used before as between-person manipulation with vouchers, incentives, information provision, advertisement, „nudges“
Conducting a within-person encouragement study

Step 1:
Define an outcome and its operationalization (e.g., experience sampling of self-reported mood)

Step 2:
Define a treatment behavior, its operationalization and the population of situations in which it can be shown (e.g., going for a run in the morning; measured with actigraphy recordings)

Step 3:
Recruit participants and negotiate individual treatment regimes

Step 4:
Implement the intervention (e.g., provide encouragements to go running via smartphone on a random 50% of mornings)

Step 5:
Estimate the treatment effect via instrumental variable estimation
Illustration of a within-person encouragement study

Observed treatment behavior

Random Encouragement

Mo Di Mi Do Fr Sa So Mo Di Mi Do Fr Sa So Mo Di Mi Do Fr Sa So Mo Di Mi Do Fr
Instrumental variable estimation

Two-stage regression „carves out“ only the exogenous part of treatment variance caused by the IV for prediction of the outcome
Two-level IV estimation as structural equation model

Level I:
Within-person level

Instrument (Encouragement) → Treatment (Behavior) → Outcome

Strong instrument!

No direct effect of instrument!

\( \sigma^2_E \)  
\( \sigma^2_T \)  
\( \sigma_{TO} \)  
\( \sigma^2_O \)
Two-level IV estimation as SEM

Level 2:
Between-person level

Level 1:
Within-person level

Diagram:
- Level 1:
  - Instrument (Encouragement)
  - Treatment (Behavior)
  - Outcome
- Level 2:
  - Parameters: \( \beta_{ET} \), \( \beta_{Int(T)} \), \( \beta_{TO} \), \( \beta_{Int(O)} \)
  - Variances: \( \sigma^2_{ET} \), \( \sigma^2_{Int(T)} \), \( \sigma^2_{TO} \), \( \sigma^2_{Int(O)} \)
Simulation study: Design

Varying strength of instrument: (.1) / .3 / .5

Varying strength of treatment effect: .1 / .3 / .5

Varying number of occasions: 50 / 100

Varying number of participants: 50 / 100

Number of replications per cell: 1000
Observed power for detecting treatment effect

- **50 subjects/50 occasions**
  - Encouragement effect: very weak (.1)
  - weak (.3)
  - medium (.5)

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Discussion: Potential problems

Weak instrument = low adherence to encouragements

Differently mediated effects of encouragement on outcome
→ Measurement of potential mediators & sensitivity analysis

Autocorrelation of residuals & sequential dependencies
→ Complex residual covariance structures
→ Theory, exploration & control

Parameter estimation with up to four correlated random effects
→ More simulation work required
FLUX
Assessment of Cognitive Performance
FLUctuations in the School ConteXt

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Project FLUX

Ambulatory assessment of working memory performance, affect, and potential antecedents (sleep, physical activity, motivation, ...)
- 3 to 4 times daily (in and out of school) for a month
- with 110 elementary school children (age 8-11)

→ systematic fluctuation of working memory performance
  (Dirk & Schmiedek, 2016; Journal of Educational Psychology)

→ systematic fluctuation of different affect dimensions
  (Leonhardt et al., 2016; Psychological Assessment)

→ coupling of sleep variables and working memory performance
  – with reliable random effect of sleep quality
  (Könen et al., 2015; Journal of Child Psychology and Psychiatry)

→ coupling of sleep variables and affect dimensions
  – with reliable random effects of sleep quality
  (Könen et al., 2016; Journal of Experimental Child Psychology)
Outlook: Interventions tailored to individual couplings

Baseline Phase
- Working memory
- Sleep duration
- Working memory
- Physical activity

Identification of coupled variables

Intervention Phase
- Experimental manipulation
- Evaluation of causal effect

"Go to be early today"

"Play ball games during next break"

Goal:
- Long-term behavioral change and outcome improvement
Summary

Investigation of (relatively immediate and short-lived) causal effects underlying observed within-person couplings

... in ecologically valid contexts

Broadening of the applicability of single-case experimental designs

Perfectly suited to smartphone-based self-experimentation with the goal of „self-enhancement“