Carl von Ossietzky Universität Oldenburg

DEPARTMENT OF PSYCHOLOGY
CARL VON OSSIETZKY UNIVERSITY OLDENBURG

Practice: Evaluation Research

Session 02 - **MLM and CSM**

psy112 - Evaluation Research

Faculty VI / UOL

Summer term 2025

Content

1. Setting Up Environment
2. Mixed ANOVA
3. Multi-level Modeling section
4. Change Score Model

Setting Up Your Environment

- **Course Book:** The main reference for PSY112-ER is available online.
  `Access the PSY112-ER Book here`
- **Computing Environment Options:**
  - Utilize the environment established for PSY126 (setup guide: `PSY126 Setup`), OR
  - Use the environment we configured during our first practical session for this course.
- **Core Tool - R Python Integration:** We will be using the ‘rpy2‘ package in Python. This allows us to execute R scripts and leverage R’s statistical capabilities within our Python (Jupyter) environment.
- **Verify Your Setup:** Please **run the ‘test.ipynb‘ Jupyter Notebook** provided on StudIP. This will help confirm that ‘rpy2‘ and your overall environment are functioning correctly.
- **Troubleshooting Support:** If you encounter errors during setup or when testing, refer to the PSY126 setup guide, specifically the section on ”Potential Issues”.
  (`View PSY126 Troubleshooting`)

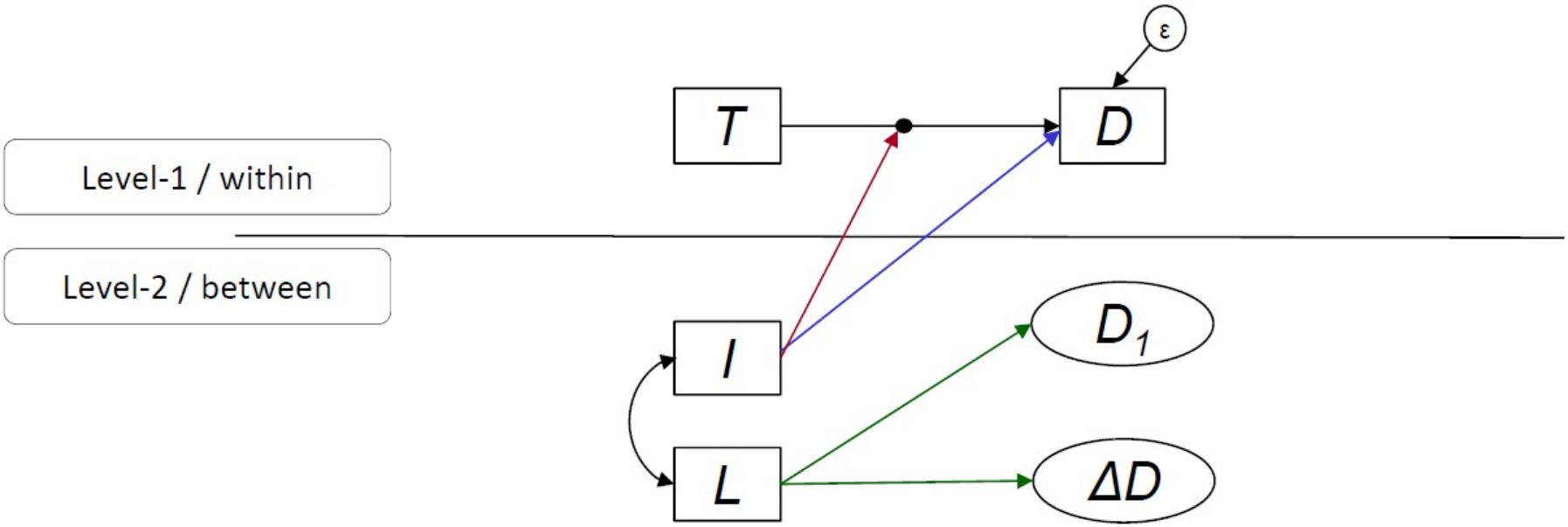
Mixed ANOVA

Building on purely between-subjects and within-subjects analyses, we now introduce **Mixed ANOVA**.

- **Core Idea:** Mixed ANOVA is used for research designs that include **both**:
  - A **Between-Subjects Factor**: Comparing two or more *independent* groups of participants (e.g., treatment vs. control group).
  - A **Within-Subjects Factor**: Measuring the *same* participants multiple times or under multiple conditions (e.g., pre-test vs. post-test; this is the repeated measures component).
- **Purpose:** It allows us to simultaneously investigate:
  - Differences *between* the groups (main effect of the between-subjects factor).
  - Changes *within* individuals over time/conditions (main effect of the within-subjects factor).
  - The **interaction** between these factors: Does the within-person change differ depending on which group a person belongs to?

Multilevel model

- Between-person IV: Intervention (I) no/yes = 0/1
- Within-person IV : Time (T) pre/post = 0/1
- DV: Depression (D)
- Covariate: Loneliness (L)



Exercise: Write the equation for the multilevel regression model and interpret the 5 regression coefficients (colored + black) estimated in the model.

Multilevel Model Equation

This model predicts Depression score (D) based on Time (T), Intervention group (I), Loneliness (L), and their interactions.

Variables:

- D: Depression score (Level 1 DV)
- T: Time (Level 1 IV, coded 0=pre, 1=post)
- I: Intervention group (Level 2 IV, coded 0=control, 1=intervention)
- L: Loneliness (Level 2 Covariate)

Model Equation:

$$D_{ti} = b0 + b1 \cdot T_{ti} + b2 \cdot I_i + b3 \cdot (T_{ti} \cdot I_i) + b4 \cdot L_i + b5 \cdot (T_{ti} \cdot L_i) + (\text{error terms})$$

Interpretation of Coefficients

$$D_{ti} = b0 + b1 \cdot T_{ti} + b2 \cdot I_i + b3 \cdot (T_{ti} \cdot I_i) + b4 \cdot L_i + b5 \cdot (T_{ti} \cdot L_i) + (\text{error terms}_{ti})$$

$b0$: **(Intercept)**
Path: Baseline value (no specific arrow).
Interpretation: Estimated average D at pre-test ($T = 0$) for the control group ($I = 0$) when Loneliness is 0 ($L = 0$).

$b1$: **(Main Effect of Time T)**
Path: Black arrow ($T \rightarrow D$), slope for ref. group.
Interpretation: Estimated average change in D from pre- to post-test ($T = 0$ to $T = 1$) for the control group ($I = 0$) when Loneliness is 0 ($L = 0$).

$b2$: **(Main Effect of Intervention I)**
Path: Blue arrow ($I \rightarrow D$).
Interpretation: Estimated average difference in D between intervention ($I = 1$) and control ($I = 0$) groups at pre-test ($T = 0$), holding L constant.

Interpretation of Coefficients

$$D_{ti} = b0 + b1 \cdot T_{ti} + b2 \cdot I_i + b3 \cdot (T_{ti} \cdot I_i) + b4 \cdot L_i + b5 \cdot (T_{ti} \cdot L_i) + (\text{error terms}_{ti})$$

$b3$: **(Interaction Effect $T \times I$)**
Path: Red arrow (I modifying $T \rightarrow D$).
Interpretation: Estimates how much the change in D over time differs for the intervention group ($I = 1$) compared to the control group ($I = 0$), holding L constant.

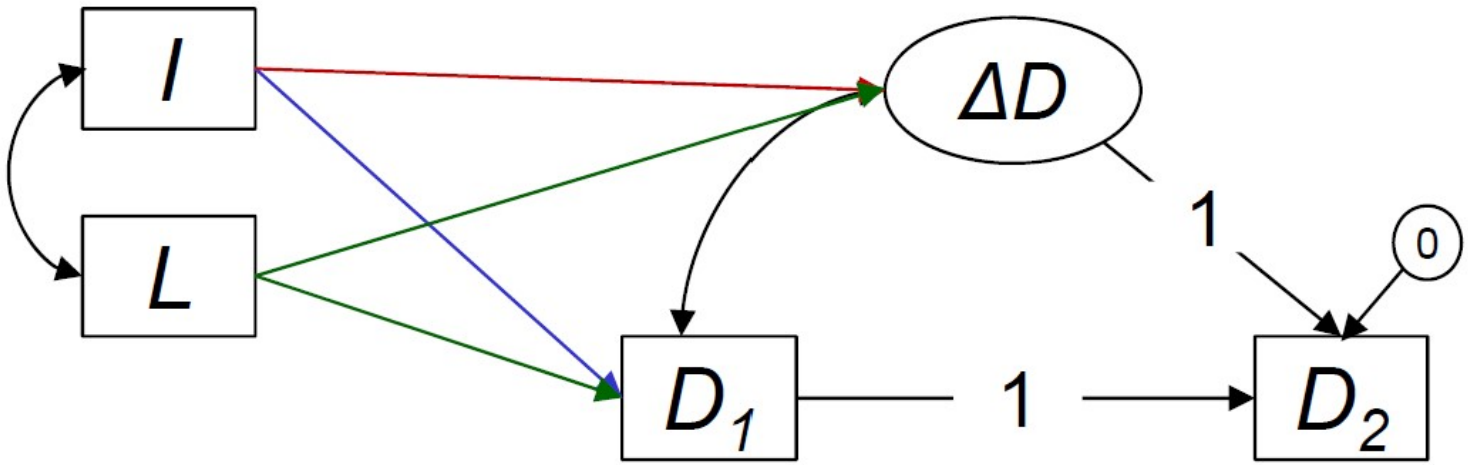
$b4$: **(Main Effect of Loneliness L)**
Path: Green arrow (top) ($L \rightarrow D$).
Interpretation: Estimated difference in D at pre-test ($T = 0$) associated with a one-unit increase in L, holding I constant.

$b5$: **(Interaction Effect $T \times L$)**
Path: Green arrow (bottom) (L modifying $T \rightarrow D$).
Interpretation: Estimates how much the change in D over time differs for each one-unit increase in L, holding I constant.

Note: The curved arrow between I and L represents their correlation, not a coefficient in this model predicting D.

Difference Score Model (Path modeling)

- Between-person IV: Intervention (I) no/yes = 0/1
- Within-person IV : Time (T) pre/post = 0/1
- DV: Depression (D)
- Covariate: Loneliness (L)



Exercise: Write the path model equations and interpret the 4 regression coefficients (colored) estimated in the model.

Difference Score Path Model: Equations

This path model analyzes the predictors of baseline depression (D_1) and the change in depression (ΔD) from pre-test (T=0) to post-test (T=1). The change score is defined as $\Delta D = D_2 - D_1$.

Variables:

- D_1: Depression score at Time 1 (Pre-test)
- D_2: Depression score at Time 2 (Post-test)
- ΔD: Change in Depression ($D_2 - D_1$)
- I: Intervention group (0=control, 1=intervention) - Level 2
- L: Loneliness (Level 2 Covariate)

Path Model Equations:

$$D_{1i} = b0_{D1} + b1 \cdot I_i + b2 \cdot L_i + e_{D1i}$$

$$\Delta D_i = b0_{\Delta D} + b3 \cdot I_i + b4 \cdot L_i + e_{\Delta Di}$$

$$D_{2i} = D_{1i} + \Delta D_i \quad \text{(Implied by diagram)}$$

Where i denotes the individual, $b1, b2, b3, b4$ correspond to the colored

Interpretation of Path Coefficients

$$D_{1i} = b0_{D1} + b1 \cdot I_i + b2 \cdot L_i + e_{D1i}$$
$$\Delta D_i = b0_{\Delta D} + b3 \cdot I_i + b4 \cdot L_i + e_{\Delta Di}$$

$b1$: **(Effect of I on D_1)**
Path: Blue arrow ($I \rightarrow D_1$).
Interpretation: Estimated average difference in baseline depression (D_1) between intervention ($I = 1$) and control ($I = 0$) groups, holding L constant.

$b2$: **(Effect of L on D_1)**
Path: Green arrow (bottom) ($L \rightarrow D_1$).
Interpretation: Estimated average difference in baseline depression (D_1) for a one-unit increase in L, holding I constant.

Interpretation of Path Coefficients

$$D_{1i} = b0_{D1} + b1 \cdot I_i + b2 \cdot L_i + e_{D1i}$$
$$\Delta D_i = b0_{\Delta D} + b3 \cdot I_i + b4 \cdot L_i + e_{\Delta Di}$$

*b*3: **(Effect of I on ΔD)**
Path: Red arrow ($I \rightarrow \Delta D$).
Interpretation: Estimated average difference in the *change* in depression (ΔD) between intervention ($I = 1$) and control ($I = 0$) groups, holding L constant.

*b*4: **(Effect of L on ΔD)**
Path: Green arrow (top) ($L \rightarrow \Delta D$).
Interpretation: Estimated average difference in the *change* in depression (ΔD) for a one-unit increase in L, holding I constant.

Note: The curved arrow between I and L represents their correlation. The black arrows define $\Delta D = D_2 - D_1$.

Next session

Topic: Latent Change Score Model

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