Approaches for statistically evaluating individual differences in psychological processes

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Outline

- Historical trends in individual difference research
  - Focus on correlations, across-person level differences
  - Focus on process, person-specific effects
- Three statistical approaches for modeling individual differences in processes
  - Moderated multiple regression
  - Finite mixture regression model
  - Multilevel model

Historical Trends

- Individual differences are a nuisance (through early 19th century)
  - Truth is in the mean
  - All else is error
- Individual differences in *level* are important (late 19th century on)
  - Variation is important, not error
  - Grist to the mill of evolution (dawn of Darwinism)
  - Francis Galton and Karl Pearson develop regression/correlation
- Individual differences in *process* are important (emerging view)
  - Emphasis on person-specific effects
  - Requires push beyond typical design/analysis paradigm

Individual Difference Research

- Since the days of Galton and Pearson, individual difference research has been dominated by the regression/correlation framework
  - recruit N participants
  - measure X
  - measure Y
  - examine X, Y correlation or $X \rightarrow Y$ regression

The Simple Regression Model

- Let us reconsider the simple regression model

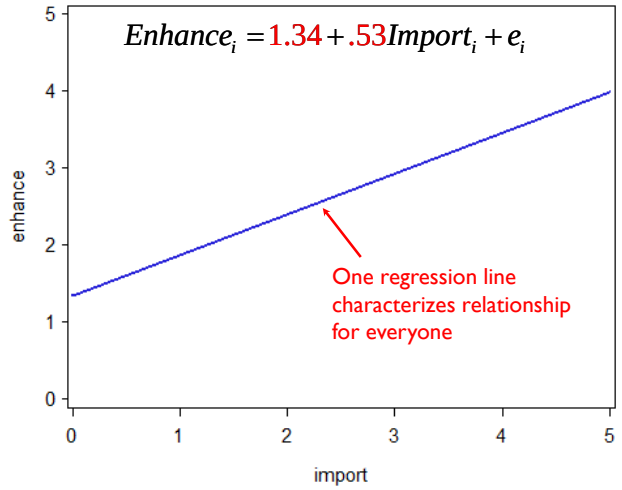
$$Y_i = \beta_0 + \beta_1 X_i + e_i$$

- Links individual differences in X to individual differences in Y
- But no individual differences in the nature of this linkage, as represented by β_0 and β_1
  - X affects Y the same way for all people.
- In sum, there are individual differences in variables (X and Y) but no individual differences in process ($X \rightarrow Y$ relationship).

Motivating Example

- Do people self-enhance (rate themselves as better than average) on characteristics that they deem important?
- Gaertner, Sedikides & Chang (2008) collected data on 60 university students in Taiwan
  - Given a trait adjective
  - Asked to rate importance to self
  - Asked to rate self on trait relative to average university student
- How does Importance (X) affect Enhancement (Y)?

Enhancement Example



The Need for Individual Differences in Process

- Nomothetic laws probably the exception rather than rule in psychological research
- Often reason to believe that psychological processes vary in strength or nature across individuals
- How best to characterize these individual differences in process?
- Three possibilities…

Moderated Multiple Regression

- One way to introduce individual differences in process is through moderation effects
- Suppose we add the moderator variable Z to our model

$$Y_i = \beta_0 + \beta_1 X_i + \beta_2 Z_i + \beta_3 X_i Z_i + e_i$$

- Now the intercept and slope of the Y on X regression line changes with individual differences in Z

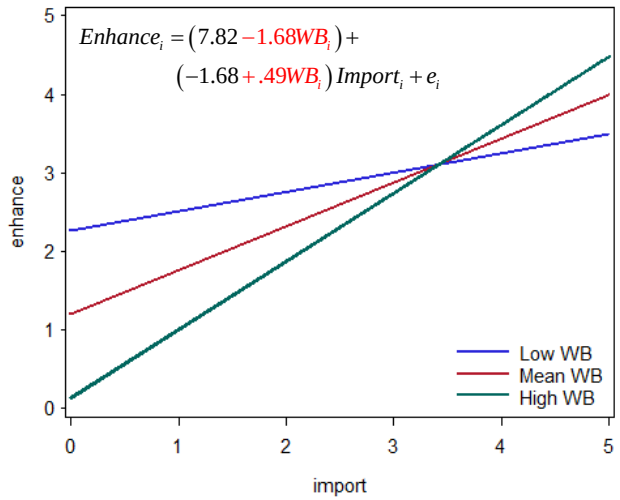
$$Y_i = \underbrace{(\beta_0 + \beta_2 Z_i)}_{\text{Intercept}} + \underbrace{(\beta_1 + \beta_3 Z_i)}_{\text{Slope}} X_i + e_i$$

Enhancement Example

- We might hypothesize that the perceived importance of a trait will have less impact on the ratings of people who are low in psychological well being
- That is, the effect of importance on enhancement may be reduced at low levels of psychological well being

$$\begin{aligned} Enhance_i &= \beta_0 + \beta_1 Import_i + \beta_2 WB_i + \beta_3 Import_i \times WB_i + e_i \\ &= (\beta_0 + \beta_2 WB_i) + (\beta_1 + \beta_3 WB_i) Import_i + e_i \end{aligned}$$

Enhancement Example



Pros and Cons of MMR

- Moderated multiple regression offers a confirmatory hypothesis-testing framework for evaluating whether processes differ across persons
- Problem is that effects only vary deterministically

$$Y_i = (\beta_0 + \beta_2 Z_i) + (\beta_1 + \beta_3 Z_i) X_i + e_i$$

Effect of X a direct linear function of Z

- Presumes knowledge of causes of process differences
  - But what if effect of X varies across persons for reasons other than Z?

Finite Mixture Regression

- Another option is to use a finite mixture model
- Assumes that the population is composed of a small number of groups (classes) characterized by different relationships between X and Y

$$Y_i = \beta_{0c} + \beta_{1c} X_i + e_i$$

where $c = 1, 2, \ldots, K$ is the class to which person i belongs.

  - Note that intercept and slope are class-specific.

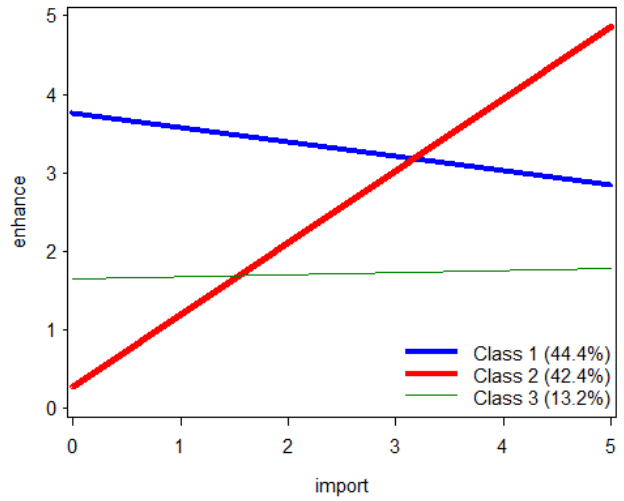
- Unlike MMR, however, classes are not observed moderator variables, they are inferred from the patterns in the data.

Enhancement Example

- We might hypothesize that ratings for a trait may be higher/lower, and more/less impacted by importance for some people than others.
  - Even if this process variation is continuous, small number of classes may provide a useful approximation
- That is, the effect of importance on enhancement is class-specific

$$Enhance_i = \beta_{0c} + \beta_{1c} Import_i + e_i$$

Enhancement Example



Pros and Cons of Finite Mixture Models

- Finite mixture regression offers an exploratory tool for identifying whether psychological processes differ across types (classes) of individuals.
- Results are, however, highly sensitive to
  - Violation of distributional assumptions (i.e., conditional normality of Y)
  - Violation of functional form (i.e., linear relationship between X and Y)
  - Instability at low sample sizes (N=60 probably too small)
- Effects are *class*-specific, not *individual*-specific.
  - 3 classes are a coarse approximation of potential range of individual differences

Multilevel Modeling

- A third approach is even more promising for evaluating individual differences in process
- Begins with a change in design
  - If we want to estimate individual-specific effects, we need to observe not just inter-individual variability but also intra-individual variability
  - Must make multiple observations on X and Y per person
- Allows us to ask the questions
  - For a given individual, how is variation in Y related to variation in X?
  - Are there individual differences in this relation?
  - To what extent can we predict these individual differences?

Change in Design

Old Design

- recruit N participants
- measure X
- measure Y
- fit $X \rightarrow Y$ regression

New Design

- recruit N participants
- Assess T times
  - measure X
  - measure Y
- fit $X \rightarrow Y$ multilevel model

Analysis

- We can now posit the following model:

$$Y_{ti} = \beta_{0i} + \beta_{1i}\dot{X}_{ti} + e_{ti}$$

where $\dot{X}$ is centered about the person mean, i.e., $\dot{X}_{ti} = X_{ti} - \bar{X}_i$

  - more on this later…

- This model links *intra-individual* differences in X to *intra-individual* differences in Y
- Permits individual differences in the nature of this linkage, as indicated in the i subscripts for β_{0i} and β_{1i}
  - The effect of X on Y may be different across people
  - Conventionally assumed that β_{0i} and β_{1i} normally distributed

Enhancement Example

- In fact, Gaertner, Sedikides & Chang (2008) asked each participant to rate 14 traits
- Given these multiple observations per person we can use a multilevel model to examine the following questions:
  - For a given individual, what is the relationship between importance and enhancement?
  - Are there individual differences in the strength and nature of this relationship?

Enhancement Example

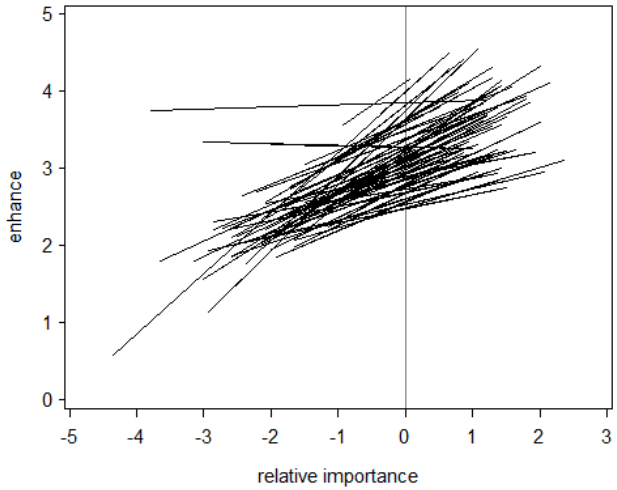
- We specify the following model

$$Enhance_{ti} = \beta_{0i} + \beta_{1i} Import_{ti} + e_{ti}$$

(assuming that β_{0i} and β_{1i} are normally distributed)

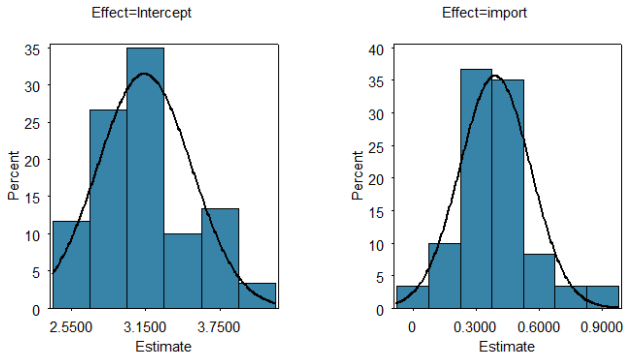
- Our results indicate that
  - the average person enhances more on traits that are regarded as more personally important
  - there are individual differences in the strength of this effect across persons, as reflected in significant variances estimates for β_{0i} and β_{1i}

Enhancement Example



Enhancement Example

- Individual differences in process reflected in different intercepts and slopes for each person



Enhancement Example

- Given these individual differences, can we predict who is most likely to enhance on important traits?
- Can return to the question of whether psychological well being plays a role – do people with lower well being show a weaker relationship between importance and enhancement ratings?

Enhancement Example

- Conceptually, we treat the intercepts and slopes of the person-specific regression lines as the outcome variable

Level 1 (intra-individual variability model)

$$Enhance_{ti} = \beta_{0i} + \beta_{1i} Import_{ti} + e_{ti}$$

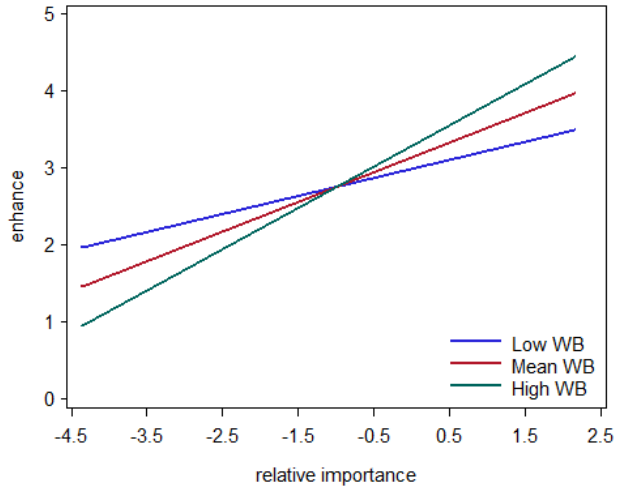
Level 2 (inter-individual differences model)

$$\beta_{0i} = \gamma_{00} + \gamma_{01} Wellbeing + u_{0i}$$
$$\beta_{1i} = \gamma_{10} + \gamma_{11} Wellbeing + u_{1i}$$

Enhancement Example

- Results from fitting this model find a significant effect of well-being on both intercepts and slopes
  - Well-being explains 10% of individual differences in intercepts
  - Well-being explains 37% of individual differences in slopes
  - Note majority of individual differences still unexplained
- Positive effect of well-being on slopes implies that people with lower psychological well being are less likely to enhance as a function of importance

Enhancement Example



Pros and Cons of Multilevel Approach

- Effects are truly individual-specific
- Allows us to explicitly examine within-person processes
  - Extent of individual differences in within-person processes
  - Predictors of individual differences in within-person processes
- Downsides are
  - Need for multiple observations per person to capture intra-individual variability
  - Assumption of normality for random effects

Conclusions

- Individual difference research is beginning to shift focus to how predictor-outcome relationships differ over individuals.
- Three possible modeling approaches for examining this issue are
  - Moderated multiple regression models
    - Assumes causes of effect heterogeneity are known
  - Finite mixture regression models
    - Allows for effect heterogeneity of unknown origin across classes of individuals
  - Multilevel regression models
    - Allows for individual-specific effects of both known and unknown origin
    - Requires more intensive data collection designs, multiple observations per person
- These (and other) approaches offer the potential to better understand individual differences in psychological processes