APA Science Training Sessions:
The Collection and Analysis of Intensive Longitudinal Data

Introduction to Intensive Longitudinal Methods

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AMERICAN PSYCHOLOGICAL ASSOCIATION

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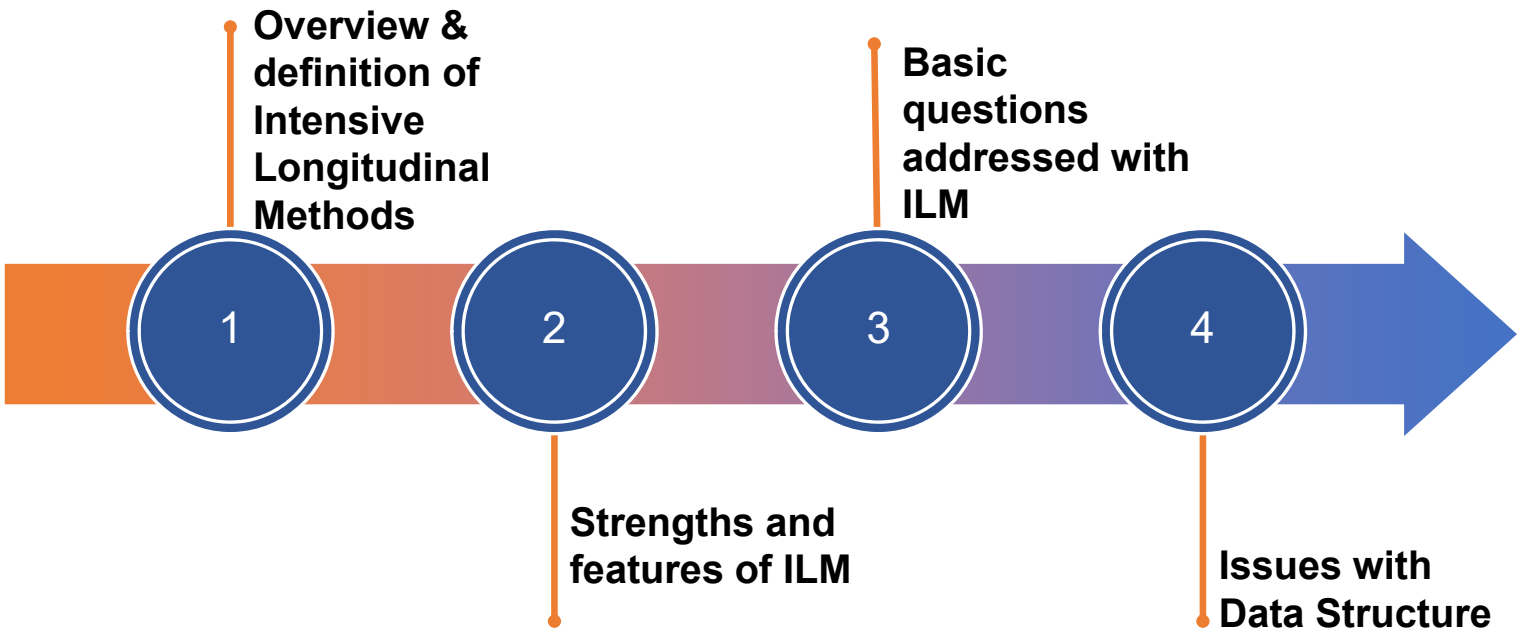
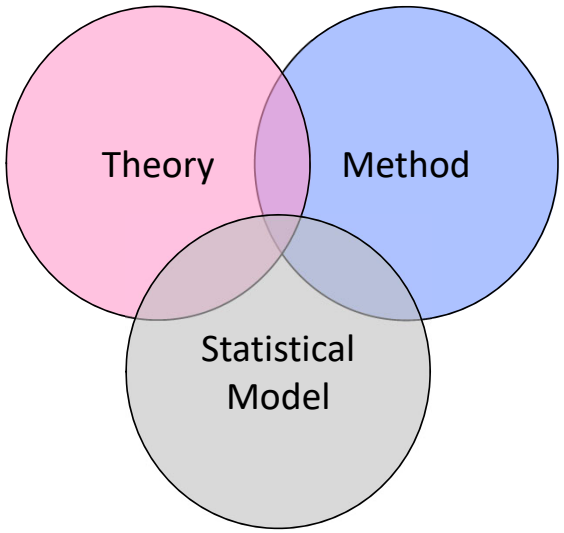
Trajectory of Talk



Theory, Method, & Statistical Model



"… ideal longitudinal research is characterized by the seamless integration of a well-articulated ***theoretical model of change****, an appropriate* ***temporal design****, and a* ***statistical model*** *that is an operationalization of the theoretical model."* *(Collins, 2006)*

Longitudinal Methods

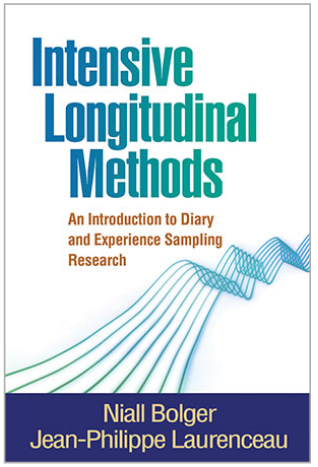
"Longitudinal methodology involves repeated, time-ordered observation of an [entity] or [entities] with the goal of identifying *processes* and causes …"

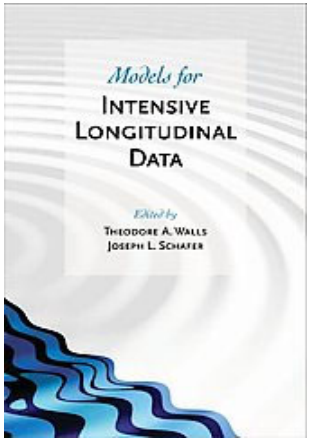
– Baltes & Nesselroade, 1979

What are Intensive Longitudinal Methods?

- **Intensive Longitudinal Methods** refer to a set of procedures that allow respondents to document their thoughts, feelings, and actions outside the walls of a laboratory

- The **"intensive longitudinal"** terminology comes from Walls and Schafer (2007)





What are Intensive Longitudinal Data?

- **Daily diary reports**
- **Experience sampling data**
- **Ecological momentary assessments**

but also:

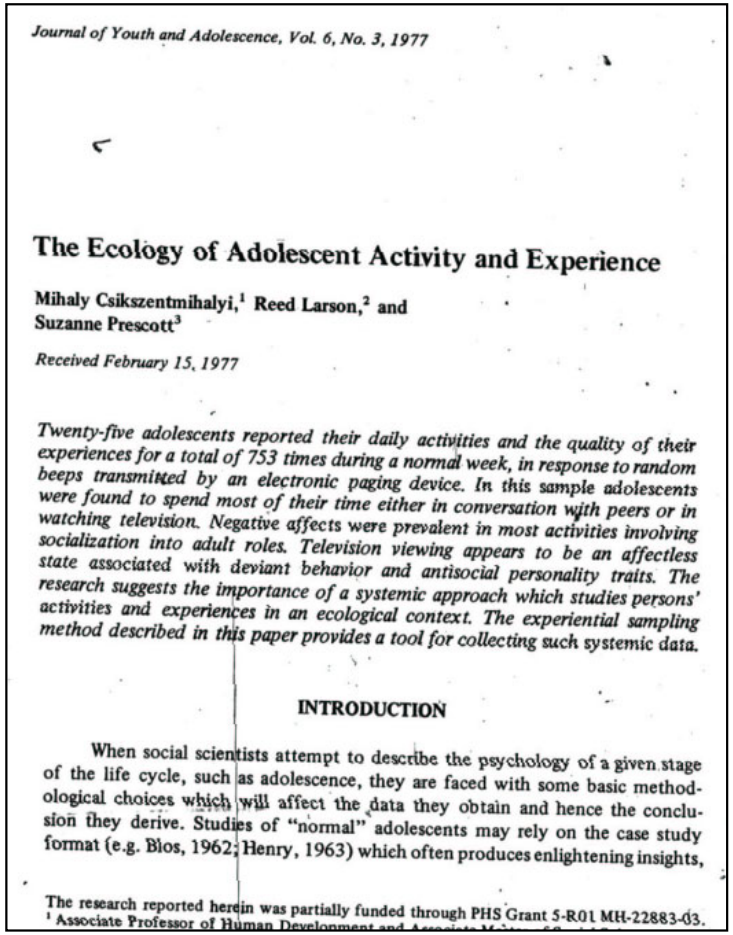
- **Physiological recordings**
- **Brain imaging data**
- **Repeated-measures experimental data**

from:

- **Individuals and dyads**

First Paper Using Intensive Longitudinal Methods?

Csikszentmihalyi, Larson, Prescott, 1977



Journal of Youth and Adolescence, Vol. 6, No. 3, 1977

The Ecology of Adolescent Activity and Experience

Mihaly Csikszentmihalyi,[1] Reed Larson,[2] and Suzanne Prescott[3]

Received February 15, 1977

Twenty-five adolescents reported their daily activities and the quality of their experiences for a total of 753 times during a normal week, in response to random beeps transmitted by an electronic paging device. In this sample adolescents were found to spend most of their time either in conversation with peers or in watching television. Negative affects were prevalent in most activities involving socialization into adult roles. Television viewing appears to be an affectless state associated with deviant behavior and antisocial personality traits. The research suggests the importance of a systemic approach which studies persons' activities and experiences in an ecological context. The experiential sampling method described in this paper provides a tool for collecting such systemic data.

INTRODUCTION

When social scientists attempt to describe the psychology of a given stage of the life cycle, such as adolescence, they are faced with some basic methodological choices which will affect the data they obtain and hence the conclusion they derive. Studies of "normal" adolescents may rely on the case study format (e.g. Blos, 1962; Henry, 1963) which often produces enlightening insights,

The research reported herein was partially funded through PHS Grant 5-R01 MH-22883-03.

[1] Associate Professor of Human Development and Associate Major of Social

Publications using "experience sampling," "ambulatory assessment," "ecological momentary assessment," or "daily diary"

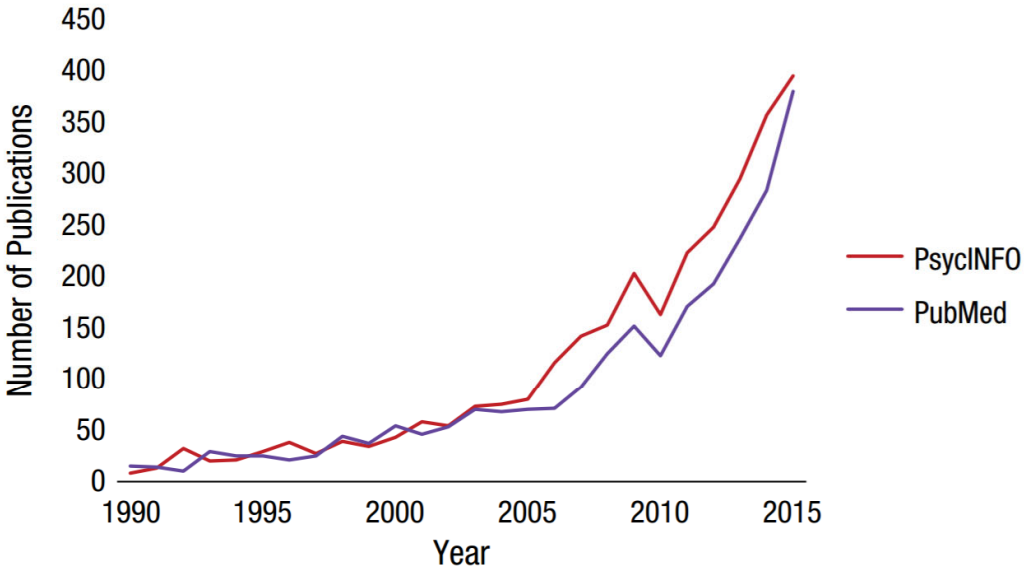
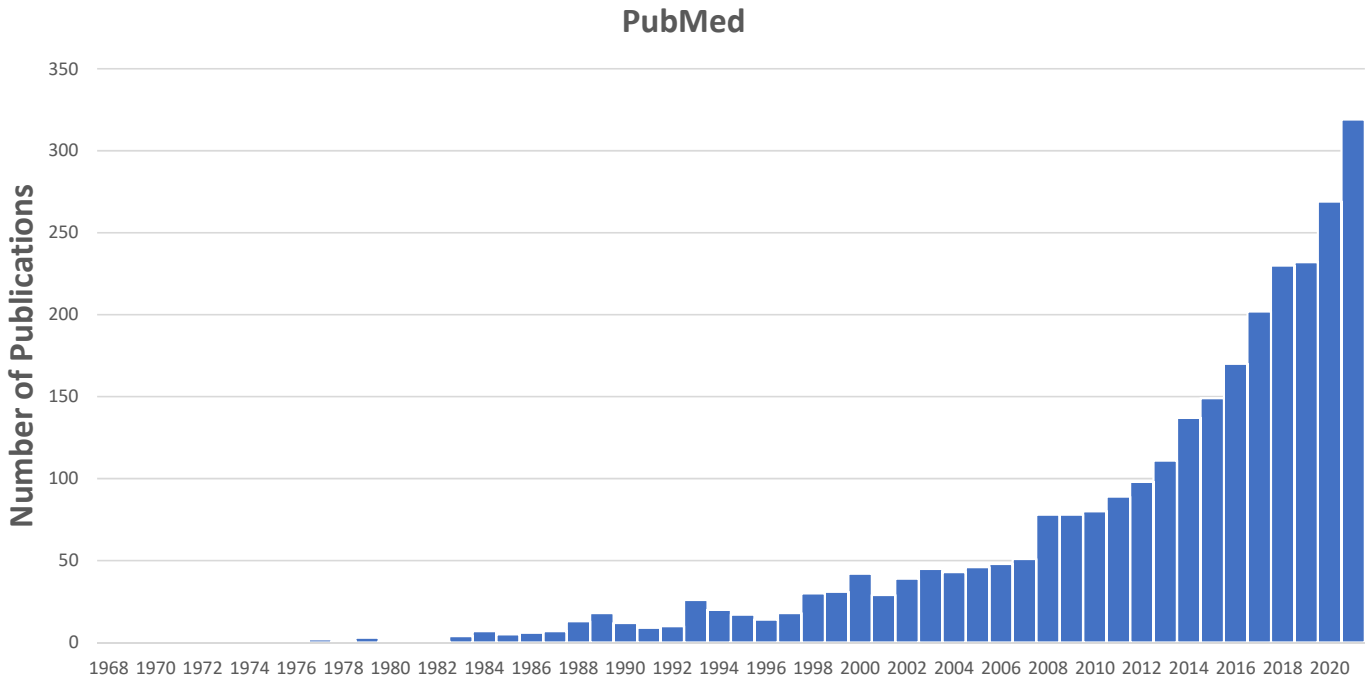


Fig. 1. Annual number of publications, based on searches using the PsycINFO and PubMed databases, with one or more of the following terms in the title, in the abstract, or as a keyword: *daily diary, experience sampling, ambulatory assessment, ecological momentary assessment*. Note that these are most likely underestimates of the actual numbers of studies based on intensive longitudinal data.

Hamaker and Wichers (2017)

Still Going Up…



Methodological Motivation

“Psychology needs to concern itself with life as it is lived.”

~Gordon Allport, 1942

- The uniqueness of the individual
- Importance of the immediate context

Intensive Longitudinal Methods

- An ***intensive longitudinal study*** is one with enough repeated measurements to model a distinct change process for each ***individual***
- ***Within-person variability*** is key
- Time scale*:* ***minutes, hours, days, and weeks*** rather than months and years
- Used to understand people's thoughts, feelings, and behaviors ***in situ***

Psychological Science *in situ*…

What is the “natural place or position” of the psychological phenomena we are interested in?

- Social Media & Body Image
- Psychopathology (e.g., depression, disordered eating)
- Self-Regulation
- Suicidal Ideation and Behaviors
- Health Behaviors (Smoking, Exercise, Sleep)

Psychological Science *in situ*…

- Although laboratory studies are powerful for theory testing, there are practical, ethical, and ecological limitations in their use

- Laboratory studies document what *can* happen…

- ILMs can document what *does* happen

A Major Source of Intensive Longitudinal Data

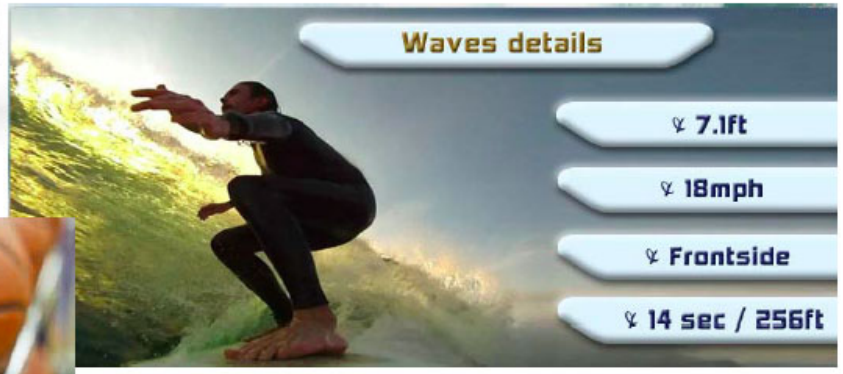
Increasing Ability to Observe Behavior

Smart pedometers

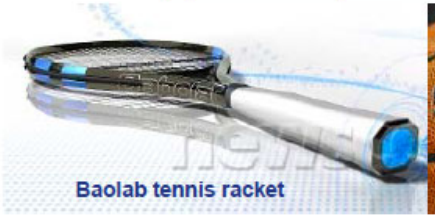
http://www.kickstarter.com/projects/597507018/pebble-e-paper-watch-for-iphone-and-android

Nike Fuel Band

Smart Shoe



Smart surfboard with GPS and IMU



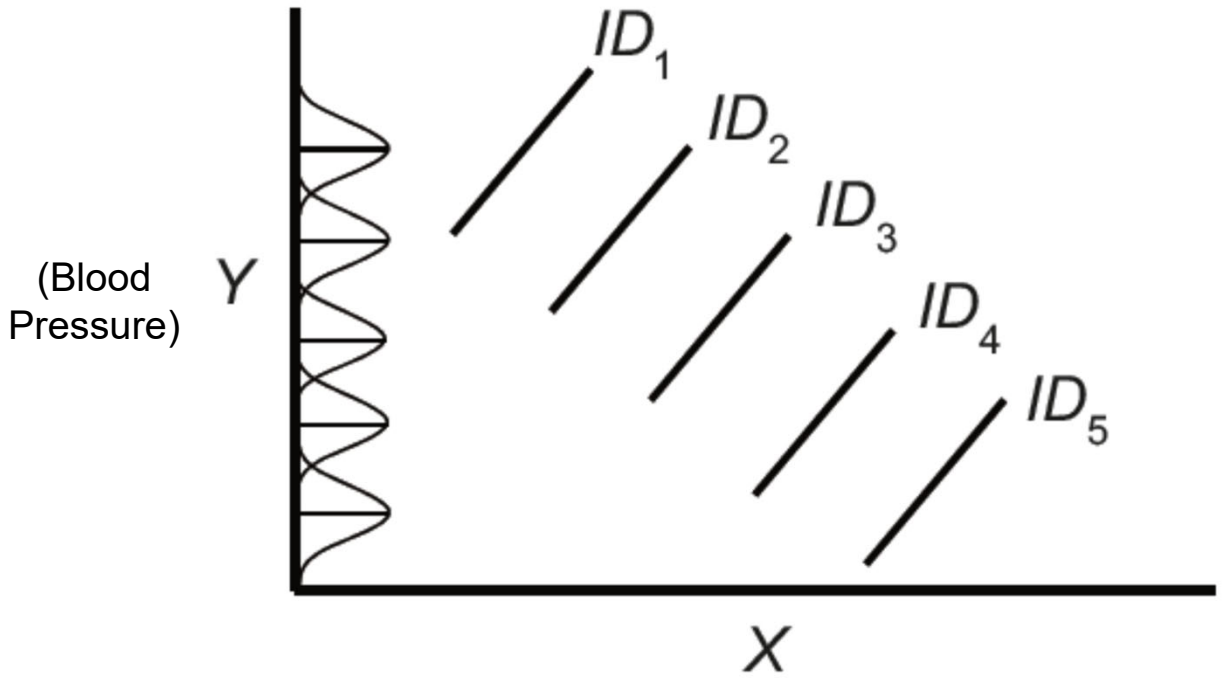
Baolab tennis racket

94Fifty sensor basketball

Strengths of Intensive Longitudinal Designs

- Extend observation of processes in more controlled settings to everyday life
- Minimize/eliminate retrospective bias
- Include everyday micro-level processes as a complement to macro-level, longitudinal designs
- **Examine how varying contexts/situations influence daily behavior, affect, or health outcomes**
- **Focus on within-person changes versus between-person differences**

When the X to Y relationship exists both <u>within-person</u> and <u>between-persons</u>



Ecological validity

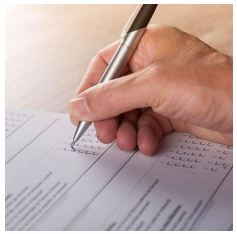
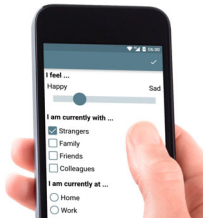
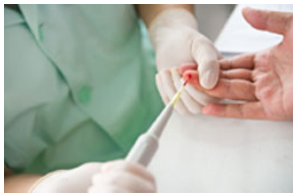
Definition: Encyclopedia of Social Psychology, 2007

External Validity

- The extent to which findings generalize across people, places, and time

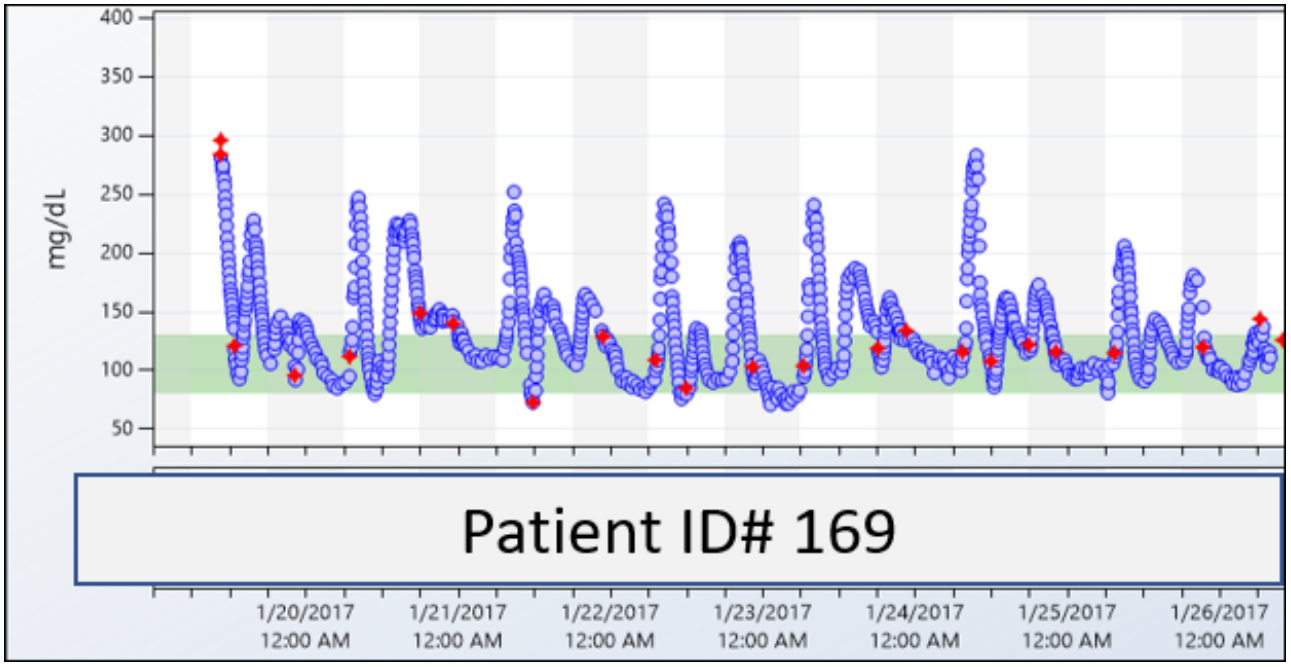
- Ecological Validity
  - More specific – the extent to which research findings generalize to … settings typical of everyday life

- Representative Design (Brunswik, 1955)
  - Representative sampling of situations – Matching the "range and characteristic distribution of conditions and condition combinations" presented in experimental design to those presented in real-world

	Laboratory	Real World
Subjective		
Objective		

Adapted from Mehl, 2007; see also Mehl & Robbins, 2012

Ecological Validity of Continuous Glucose Monitoring



ILM vs. Other Longitudinal Methods

	Intensive Longitudinal	Traditional Longitudinal
Number of time points	10-20 and more	2-6
Assessment density	Minutes, hours, days	Weeks, months, years
Assessment timescale	Momentary; minimal retrospection (e.g., “today…”)	Global (e.g., ”in past month…”)
Typical goal	Model *processes*	Model *outcomes*

Sampling Approaches

Interval-contingent	Daily diary
Signal-contingent	Experience sampling (ESM)
Event-contingent	Sleep actigraphy
Device-contingent	Ambulatory physio.

Sampling Approaches

Interval-contingent	Daily diary	Typically equally spaced intervals; same across participants
Signal-contingent	Experience sampling (ESM)	Researcher determined intervals; same across participants
Event-contingent	Sleep actigraphy	Unequal intervals; differ across participants
Device-contingent	Ambulatory physio.	Unequal intervals, rule-based; differ across participants

Sampling Approaches

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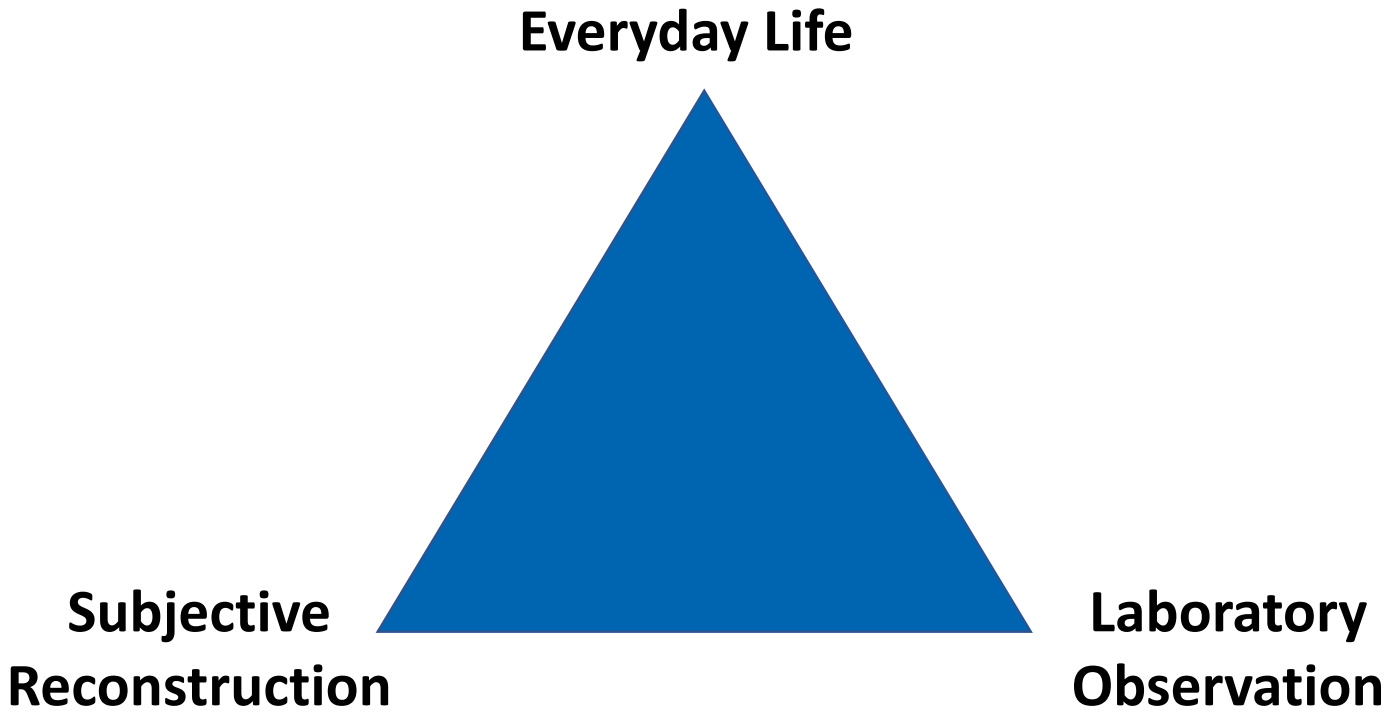
Device-contingent	Ambulatory physio.	Unequal intervals, rule-based; differ across participants
Combination of approaches	ESM + continuous glucose monitoring	Differences in time sampling and/or intervals may have important substantive and analytic implications

Three Methodological Approaches to Studying Psychological Experience



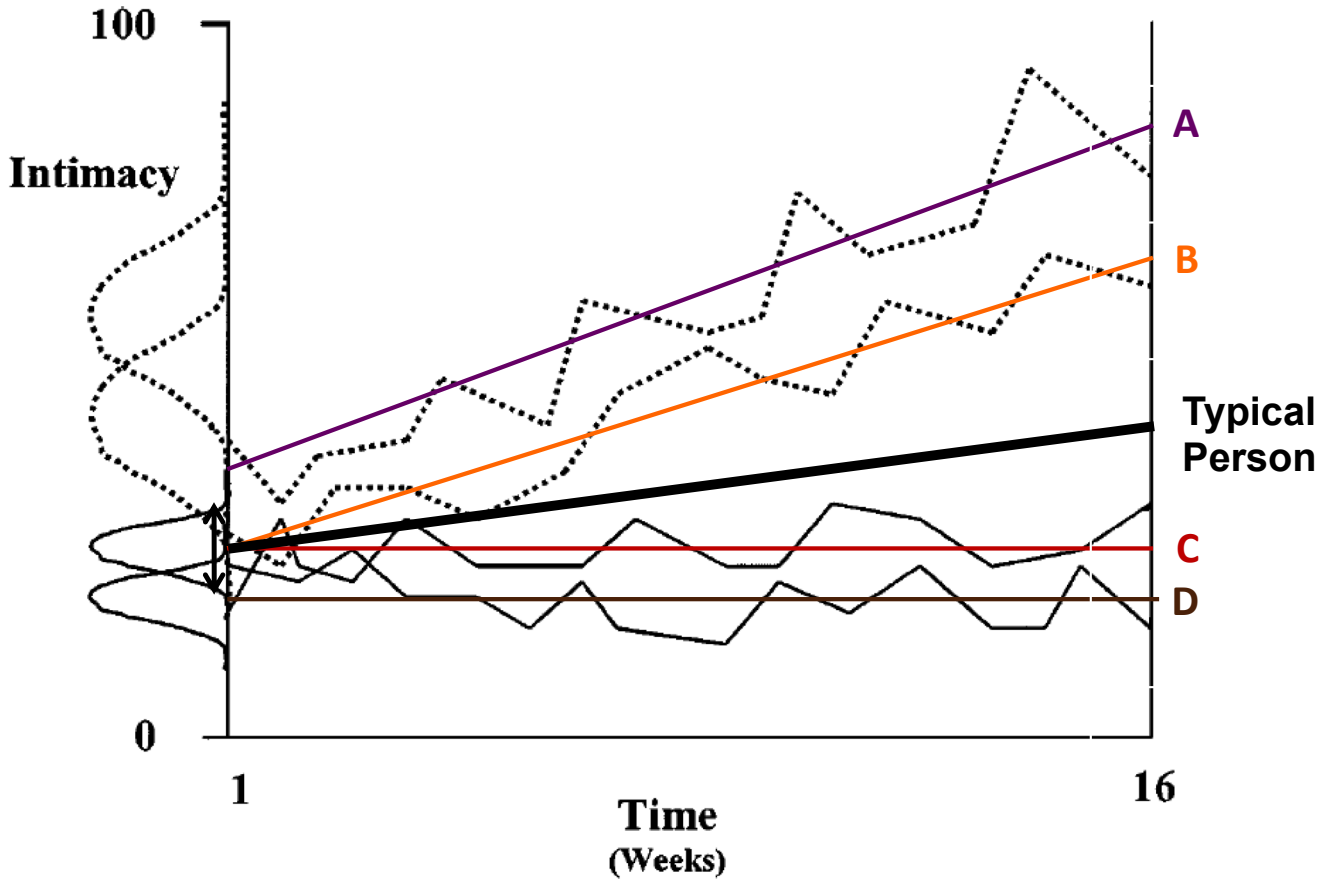
(Kahneman, 2011; Reis, 1994)

Prototypical Research Questions

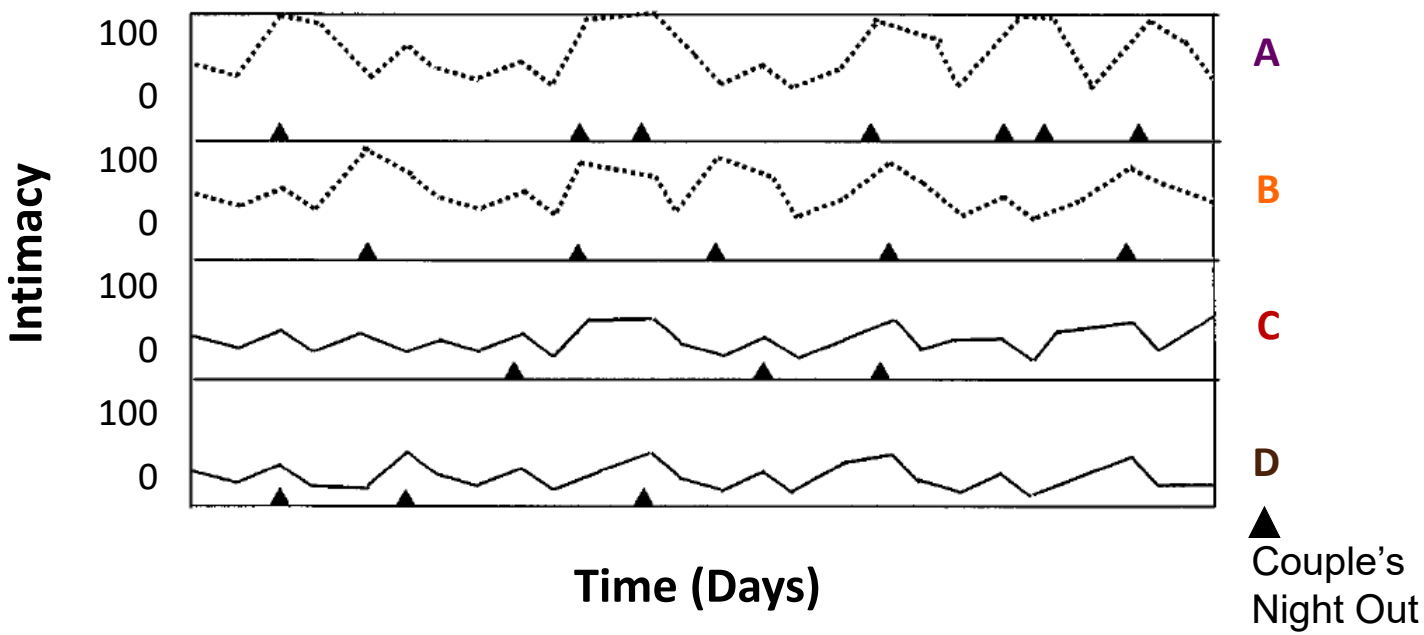
A. How does the **typical person change over time** and how much do **people differ from one another in that change?**

B. What is the **within-person process** for the **typical person** and how do **people differ from each other in these processes?**

A. Within-Person Change



B. Within-Person Process



Prototypical Research Questions

A. The first concerns tracing the course of within-person change in an outcome for the average (typical) person, capturing how much people differ from each other in that change (heterogeneity), and whether these individual differences can be modeled with person-level variables
B. The second concerns identifying the within-person process (involving a predictor that unfolds over time) for the typical person, capturing heterogeneity in this process, and modeling the heterogeneity

ILD are a Special Case of Multilevel Data

- Models for multilevel data go by many names:
  - Mixed Models
  - Mixed Effects Regression Models
  - Random Coefficient Modeling
  - Hierarchical Linear Modeling

Examples of Multilevel Data Structures

- Multilevel data involve **nesting**, with micro-units (Level-1) nested within macro-units (Level-2):
  - Students in classrooms
  - Clients in therapists
  - Patients in wards
  - Repeated measurements within persons

What is Different About Longitudinal Data?

- There is nesting of observations, but there is also a **strict ordering by time**
- Observation 1 precedes observation 2, and so on
- There is no such ordering for children in classrooms and many other multilevel data examples
- For some types of ILD, where the times of observations are fixed across time and across subjects, we can treat time as **crossed** not nested
  - e.g., in daily diary studies, day 1, day 2, day 3 have a common meaning across subjects

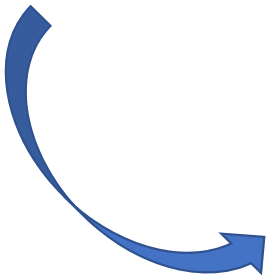
Structuring of Intensive Longitudinal Data

- Intensive longitudinal data can be structured in one of two forms:
  - **Multivariate,** where columns comprise each repeated measure of a variable and rows comprise participants (aka WIDE)
  - **Univariate,** where columns comprise variables and rows comprise repeated measurements (within participants) (aka LONG)
  - The univariate form is the most useful for modeling ILD

id	gender	BLdepression	Health1	Health2	Health3	Health4
1.00	1.00	9.00	2.10	2.90	4.50	4.50
2.00	.00	9.00	2.30	4.50	4.20	4.60
3.00	.00	10.00	2.30	3.80	4.30	6.20
4.00	1.00	8.00	1.80	2.60	4.10	4.00
5.00	1.00	10.00	3.50	4.80	5.80	7.50

WIDE
or MULTIVARIATE

LONG
or
UNIVARIATE



id	gender	BLdepression	Index1	Health
1.00	1.00	9.00	1	2.10
1.00	1.00	9.00	2	2.90
1.00	1.00	9.00	3	4.50
1.00	1.00	9.00	4	4.50
2.00	.00	9.00	1	2.30
2.00	.00	9.00	2	4.50
2.00	.00	9.00	3	4.20
2.00	.00	9.00	4	4.60
3.00	.00	10.00	1	2.30
3.00	.00	10.00	2	3.80
3.00	.00	10.00	3	4.30
3.00	.00	10.00	4	6.20
4.00	1.00	8.00	1	1.80
4.00	1.00	8.00	2	2.60
4.00	1.00	8.00	3	4.10
4.00	1.00	8.00	4	4.00
5.00	1.00	10.00	1	3.50
5.00	1.00	10.00	2	4.80
5.00	1.00	10.00	3	5.80
5.00	1.00	10.00	4	7.50

Minimal Data Set

ID_j Participant ID (1 to 5)
T_i Time (0 to 4)
X_{ij} Time-varying predictor
Y_{ij} Outcome
W_j Between predictor

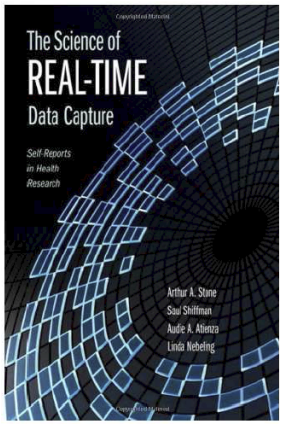
ID_j	T_i	X_{ij}	Y_{ij}	W_j
1	0	x_{11}	y_{11}	w_1
1	1	x_{21}	y_{21}	w_1
1	2	x_{31}	y_{31}	w_1
1	3	x_{41}	y_{41}	w_1
1	4	x_{51}	y_{51}	w_1
2	0	x_{12}	y_{12}	w_2
2	1	x_{22}	y_{22}	w_2
2	2	x_{32}	y_{32}	w_2
2	3	x_{42}	y_{42}	w_2
2	4	x_{52}	y_{52}	w_2
3	0	x_{13}	y_{13}	w_3
3	1	x_{23}	y_{23}	w_3
3	2	x_{33}	y_{33}	w_3
3	3	x_{43}	y_{43}	w_3
3	4	x_{53}	y_{53}	w_3
4	0	x_{14}	y_{14}	w_4
4	1	x_{24}	y_{24}	w_4
4	2	x_{34}	y_{34}	w_4
4	3	x_{44}	y_{44}	w_4
4	4	x_{54}	y_{54}	w_4
5	0	x_{15}	y_{15}	w_5
5	1	x_{25}	y_{25}	w_5
5	2	x_{35}	y_{35}	w_5
5	3	x_{45}	y_{45}	w_5
5	4	x_{55}	y_{55}	w_5

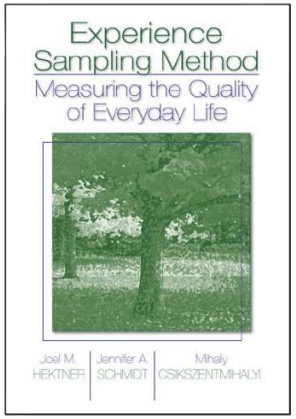
Working with Multilevel Software

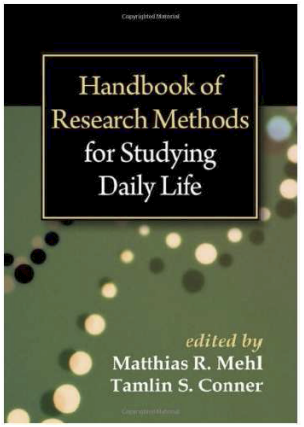
- SPSS MIXED
- SAS PROC MIXED
- R lme4 package
- Stata xtmixed
- HLM
- Mplus
- MLwiN

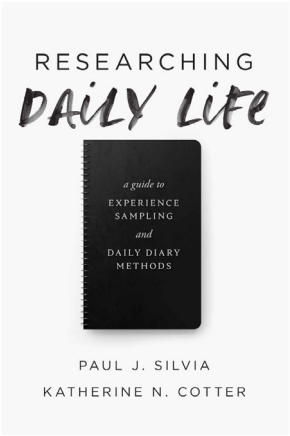
- We recommend being familiar with more than one program
- Each have specific strengths and weaknesses
- Replication across programs provides insight into the general modeling approach

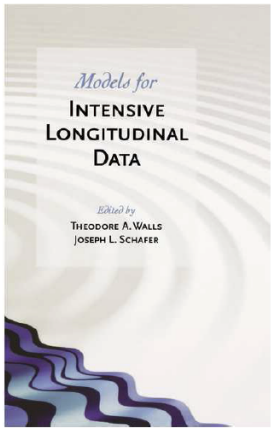
Some Books to Recommend:

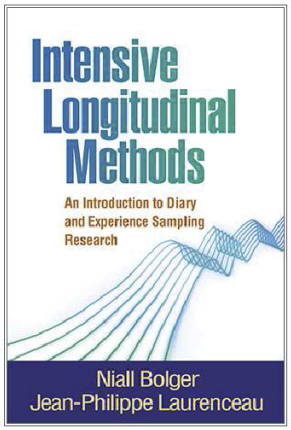












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