

A Two-Day Workshop in “Longitudinal Structural Equation Modeling”

Created by:

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Longitudinal Research Institute

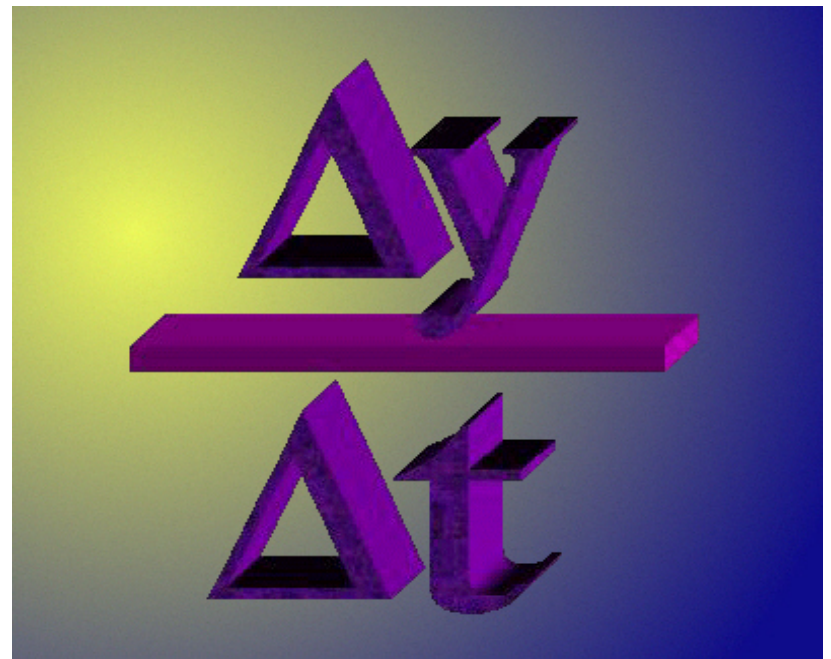
Presented by:

Jack McArdle,

University of Southern California

CALDAR August 10-11, 2010

And prepared as a Textbook for use
in Behavioral and Life Sciences at
the Graduate Level



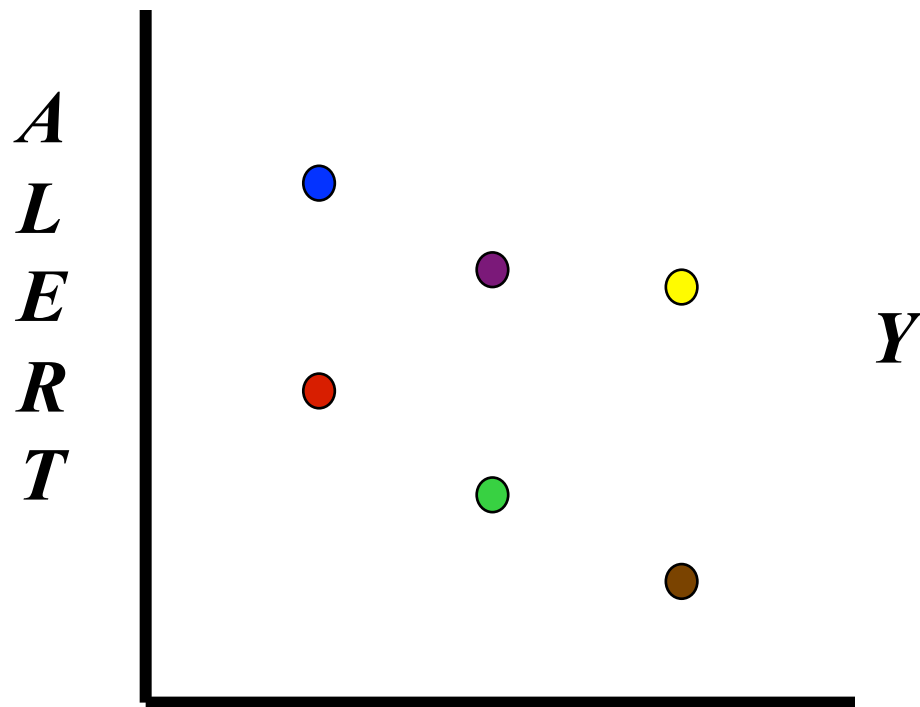
The “Longitudinal” themes

Methods = There are a variety of ways to study change over time, but many involve longitudinal data. A variety of the most useful of these will be discussed and illustrated

Models = The literature contains a rapidly increasing variety of mathematical and statistical models. Some of the most useful models will be defined and illustrated.

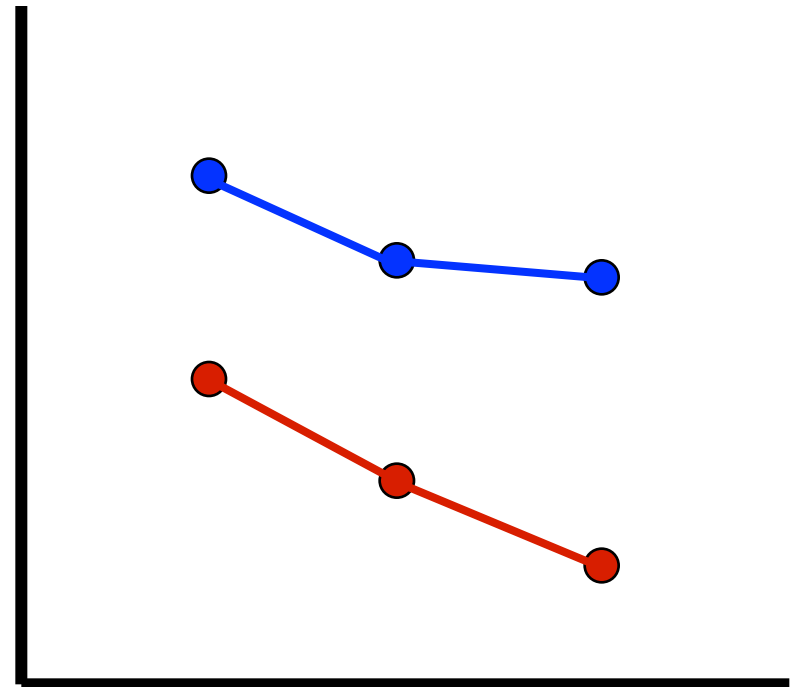
Measurement = These topics are often overlooked, but they are fundamental to the nature of change. Some new approaches will be discussed and illustrated

Cross-sectional versus longitudinal data



*X=TIME
OF DAY*

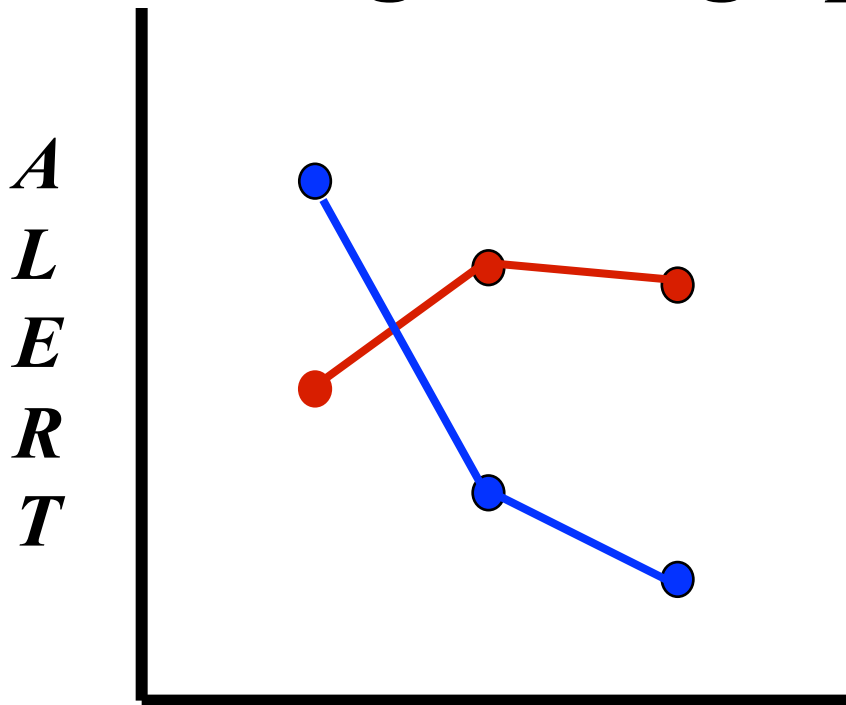
Cross-sectional Measurement



*X=TIME
OF DAY*

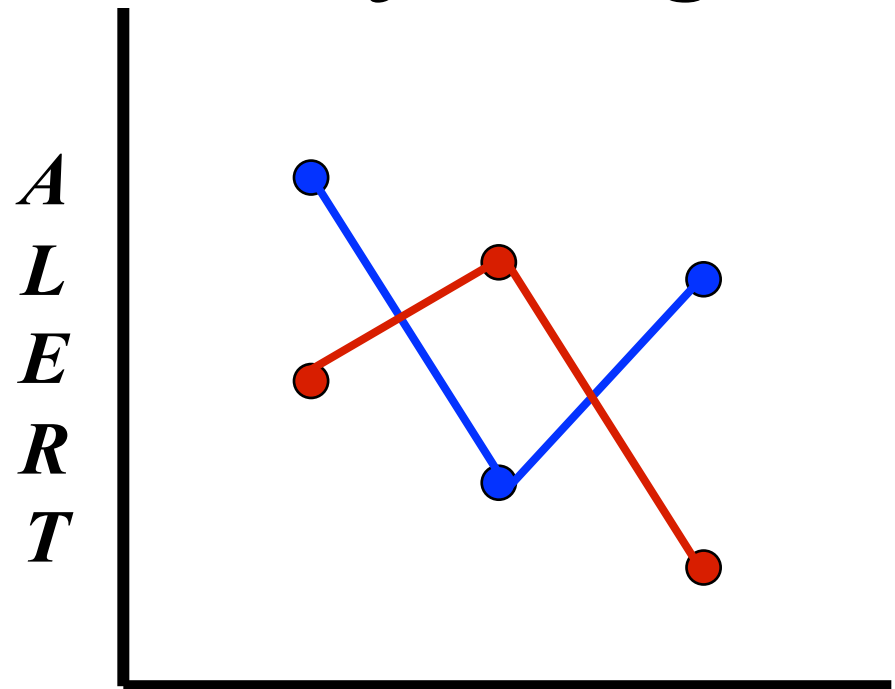
Longitudinal Measurement

Longitudinal data are most useful in distinguishing “patterns of change”



*X=TIME
OF DAY*

Longitudinal Pattern 2



*A
L
E
R
T*

*X=TIME
OF DAY*

Longitudinal Pattern 3

Structure based on “Five Objectives of Longitudinal Research” (from Nesselroade & Baltes, ‘79)

1. Identification of *intra-individual* change
2. Direct identification of *inter-individual* differences in intra-individual change
3. Analysis of *inter-relationships* in change
4. Analysis of *causes (determinants)* of *intra-id* changes
5. Analysis of *causes (determinants)* of *inter-id* differences in intra-individual change

Math/Stat Approach Based on Structural Equation Modeling (SEM)

- Linear SEM (LISREL) is popular and has practical value. Most or all prior parametric models clarified, including ANOVA, Linear Regression, IRT and Factor Analysis.
- Some complex ideas can be directly tested this way, including reliable factor regression, latent constructs, and incomplete data bias. *Most of these issues are important for longitudinal research!*
- The “causal models” in SEM provides no more “causal analysis” than other forms of data analysis -- maybe less if data are weak and we count more heavily on the modeling analysis!

Day I: “Dealing with Incomplete Data”

1: Introduction to Imputation Solutions for Incomplete Longitudinal Data

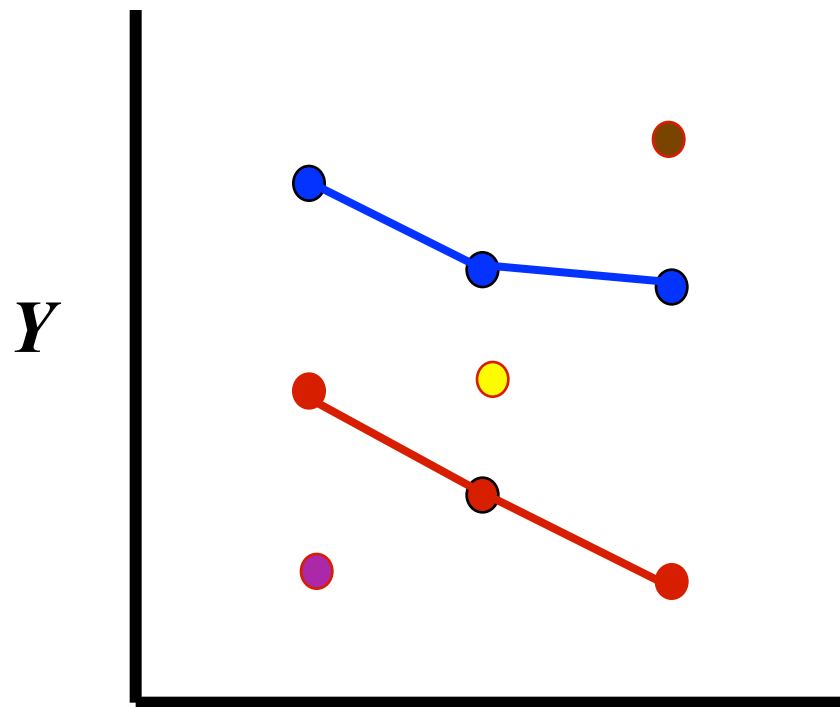
2: Alternative Likelihood Approaches for Incomplete Longitudinal Data

3: Creating or Planning Incomplete Data

Dealing with incomplete data as groups with comparable patterns

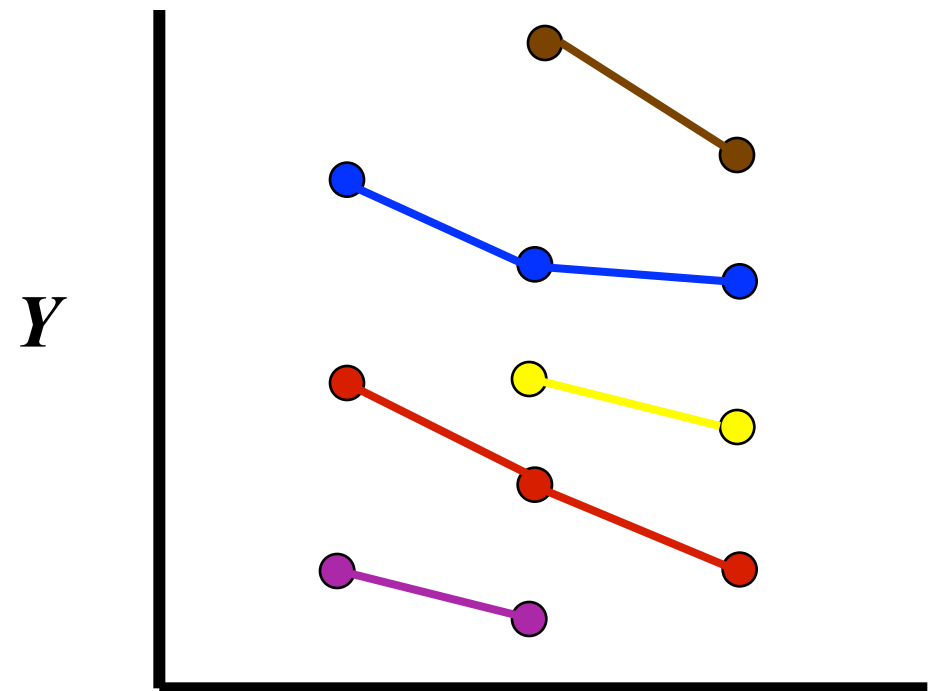
- Practical problems occur in any longitudinal study, including initial subject self-selection and subject dropout (attrition) or designed lack of measurement
- There are many new and innovative analyses for these general problems --- including SEM, Multiple Imputation, Gibbs Sampling (Little & Rubin, 1987)
- The SEM presented here rely on a *likelihood-based* approach to incomplete patterns (e.g., multiple groups), and this approach is identical to most “unbalanced” or “mixed” or “multilevel” models
- In these SEM, no data are “imputed” – the parameters are estimated using “all available data” (not “complete cases”).

Dealing with incomplete longitudinal data



$X=TIME$

Adding Incomplete Data



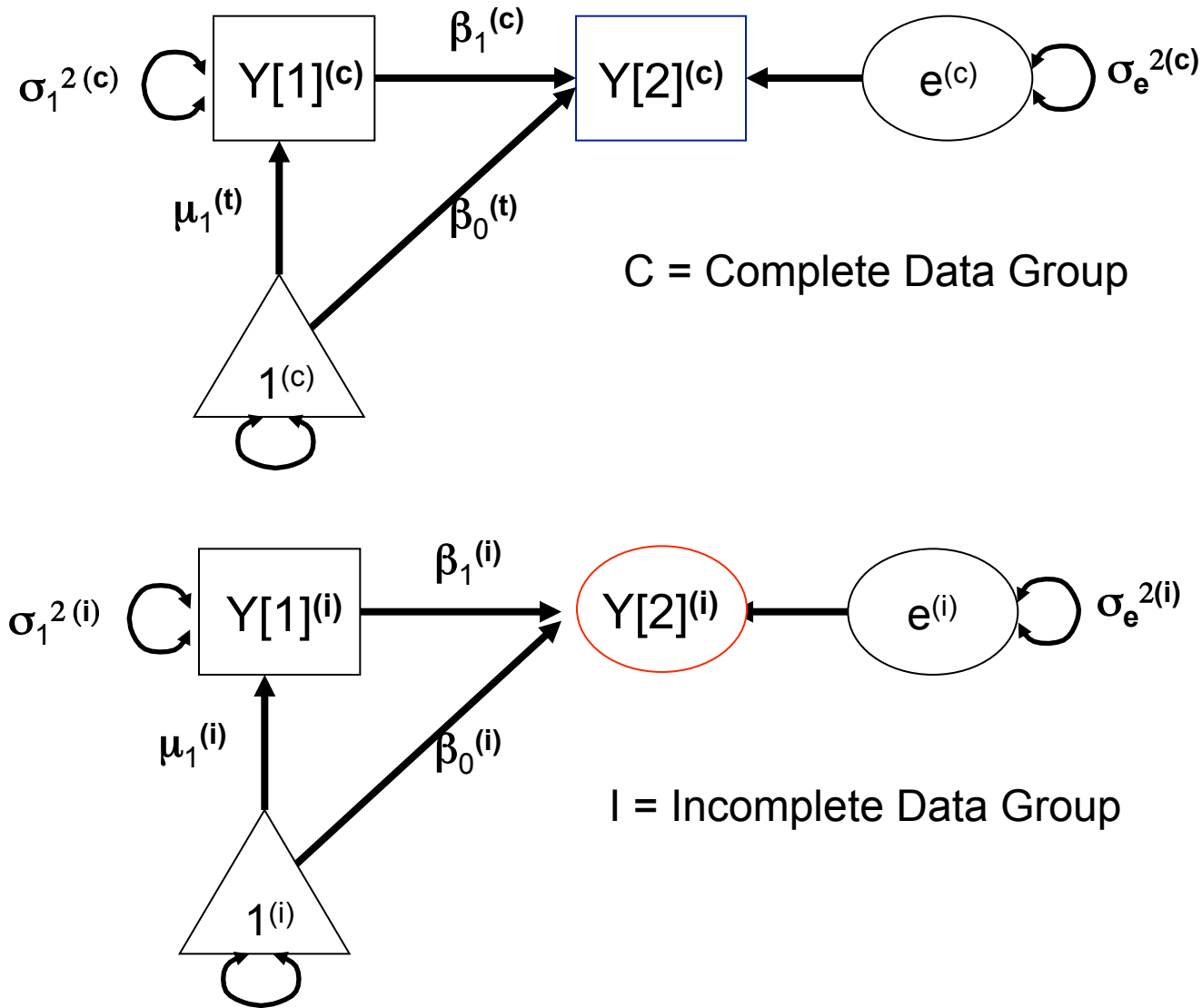
$X=TIME$

Adding Incomplete Pairs

Available SEM computer programs

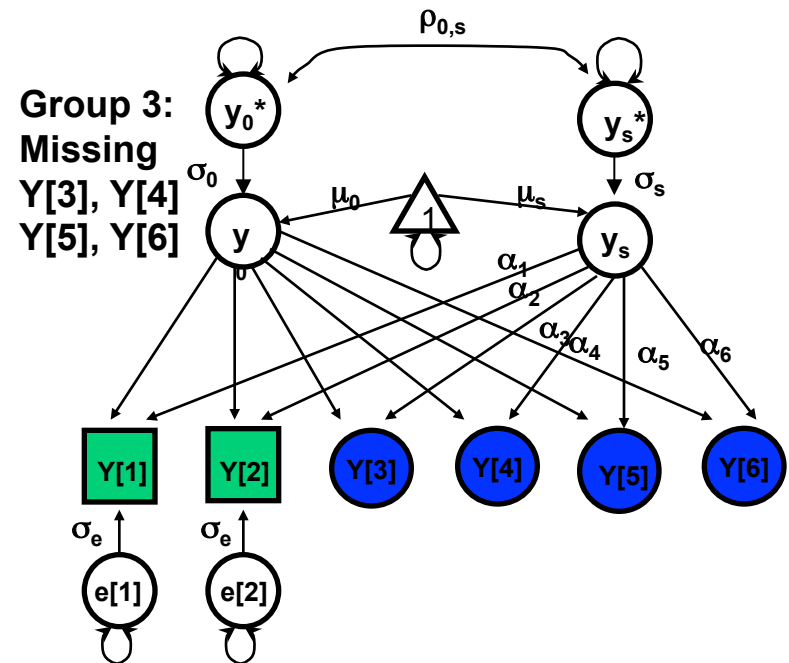
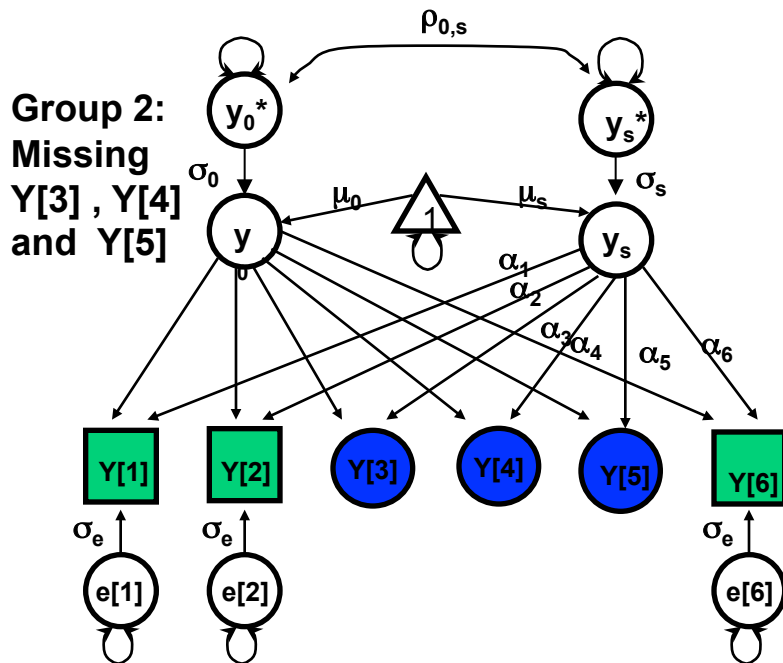
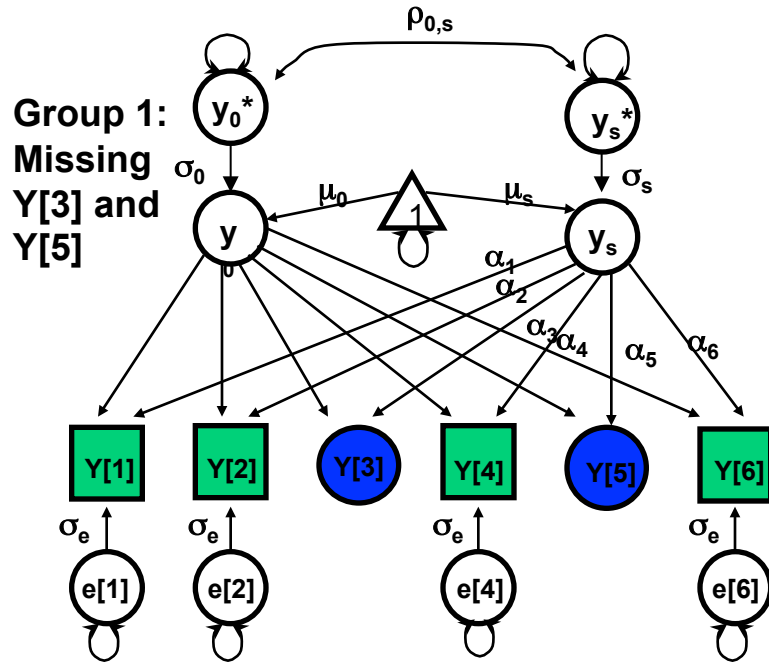
- *LISREL* – original and most well-known program (+notation) by Joreskog & Sorbom
- *Mx* – the general and freely available program by Neale
- *Mplus* –the most general program by Muthen & Muthen
- Other SEMs part of packages – *AMOS* (SPSS), *CALIS* (SAS), *EQS*(BMDP), GLIM (STATA), *RAMONA* (SYSTAT), and *sem* (R)
- Other programs are not marketed as SEM, but can give equivalent results – SAS MIXED, NLMIXED, MLwin, wWinBUGS, and LatentGOLD.
- If the model is identical, all programs should give exactly the *same results for the same model*. Of course, each program differs in some ways that may be important to a user (e.g., data entry, model syntax, model options, etc.)

A general multiple group auto-regression model with incomplete data differences

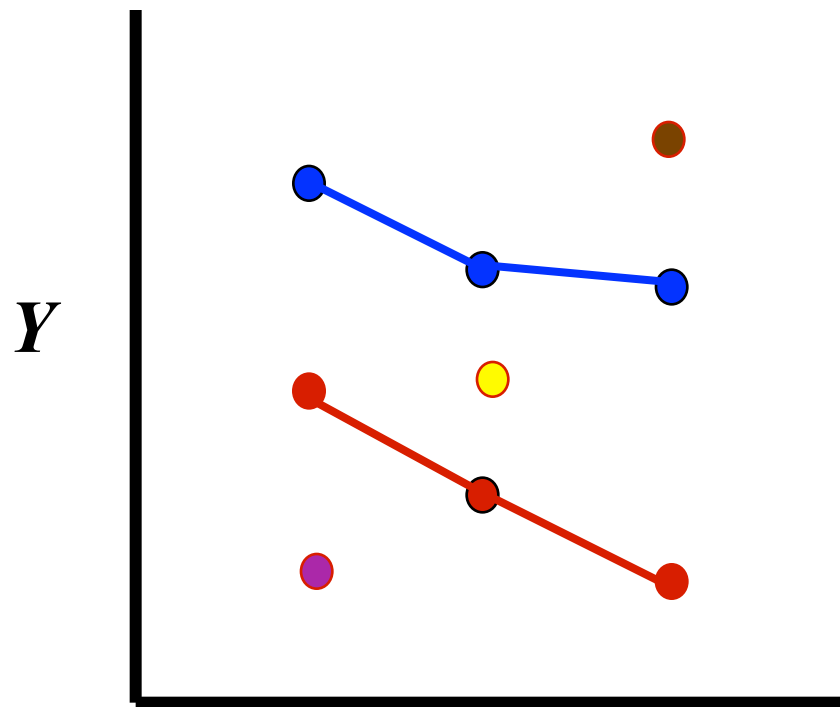


Three groups with different patterns of incomplete data.

Note: The key “untested” assumption is the groups all come from the same population, selected only by differences in the factor scores -- i.e., that factorial invariance holds.

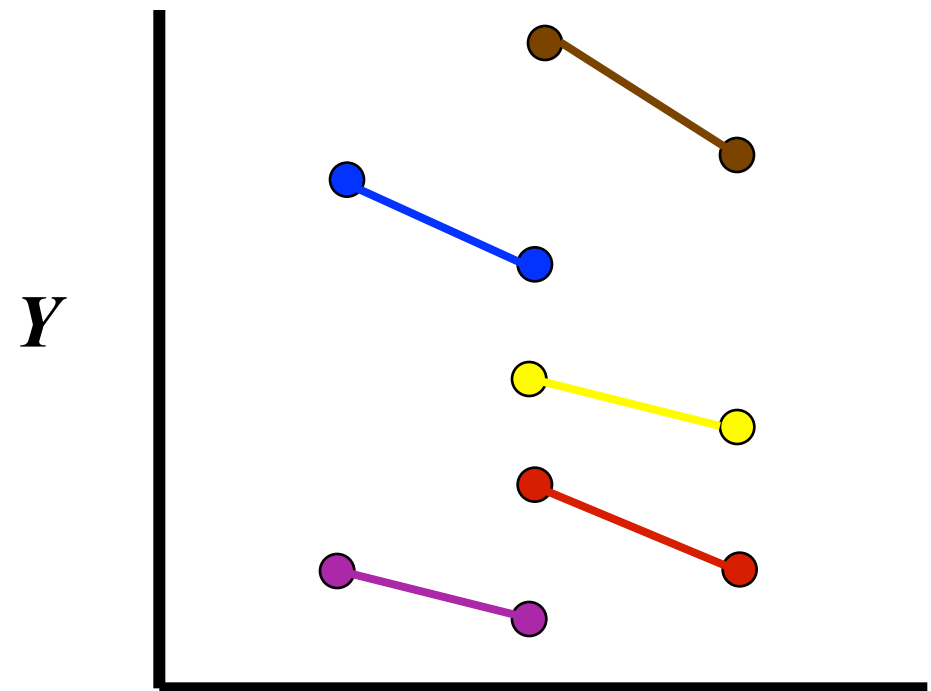


Dealing with incomplete longitudinal data



$X=AGE$

Adding Incomplete Data



$X=AGE$

Analyzing Only Pairs

Day II: “Causal Inference from Longitudinal Data”

1: Introduction to Causal Inference in Observational Data

2: Alternative Approaches for Causal Inference with Multivariate Two-Occasion data

3: Alternative Approaches for Causal Inference with Multivariate Multi-Occasion Data

Alternative RCT based SEM

(from McArdle & Prindle, 2008)

Figure 2a: A path diagram of possible impacts in a two-group training experiment

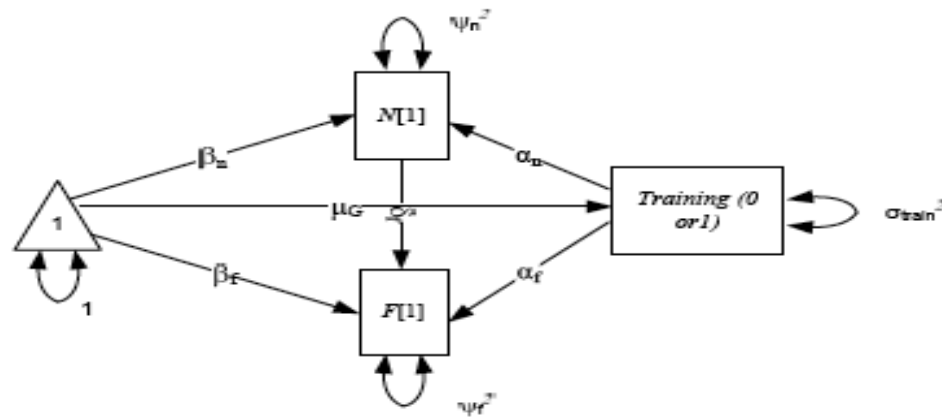
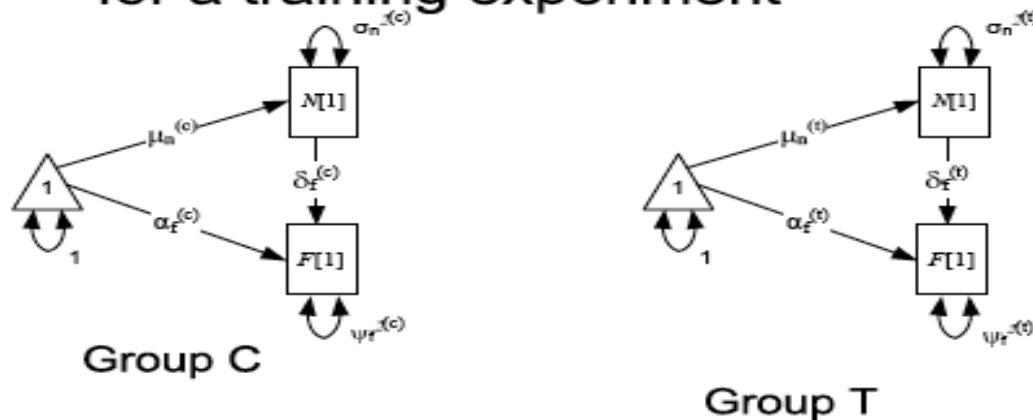
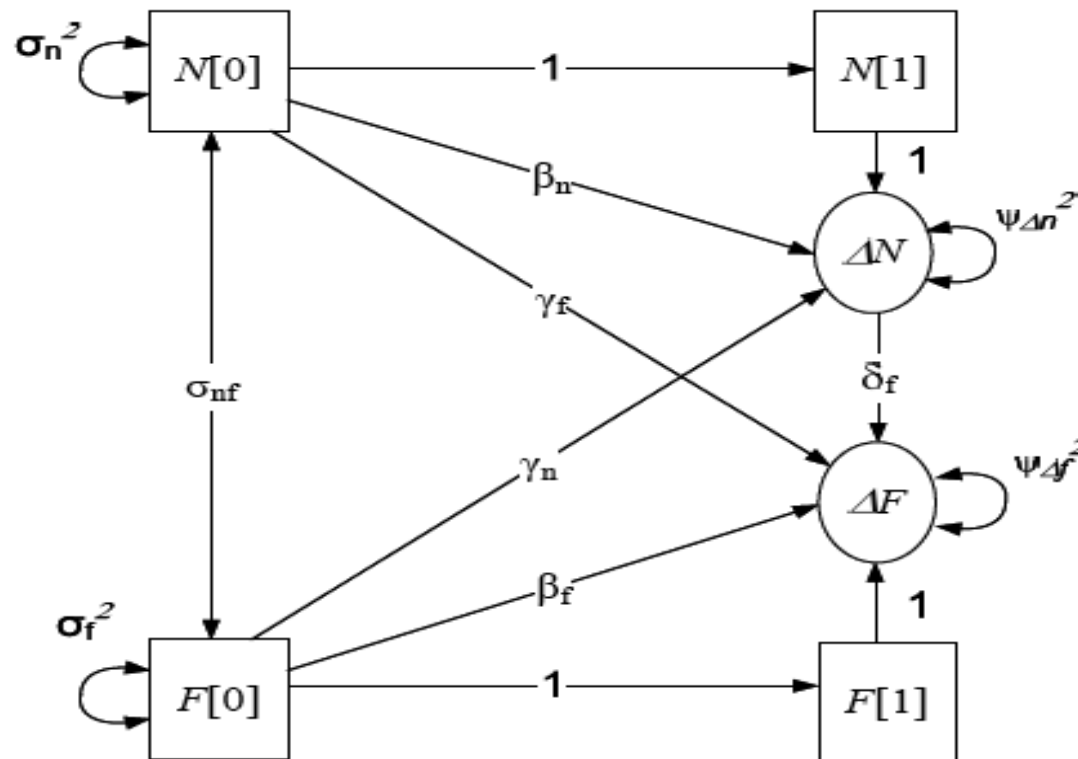


Figure 2b: A two-group SEM for a training experiment



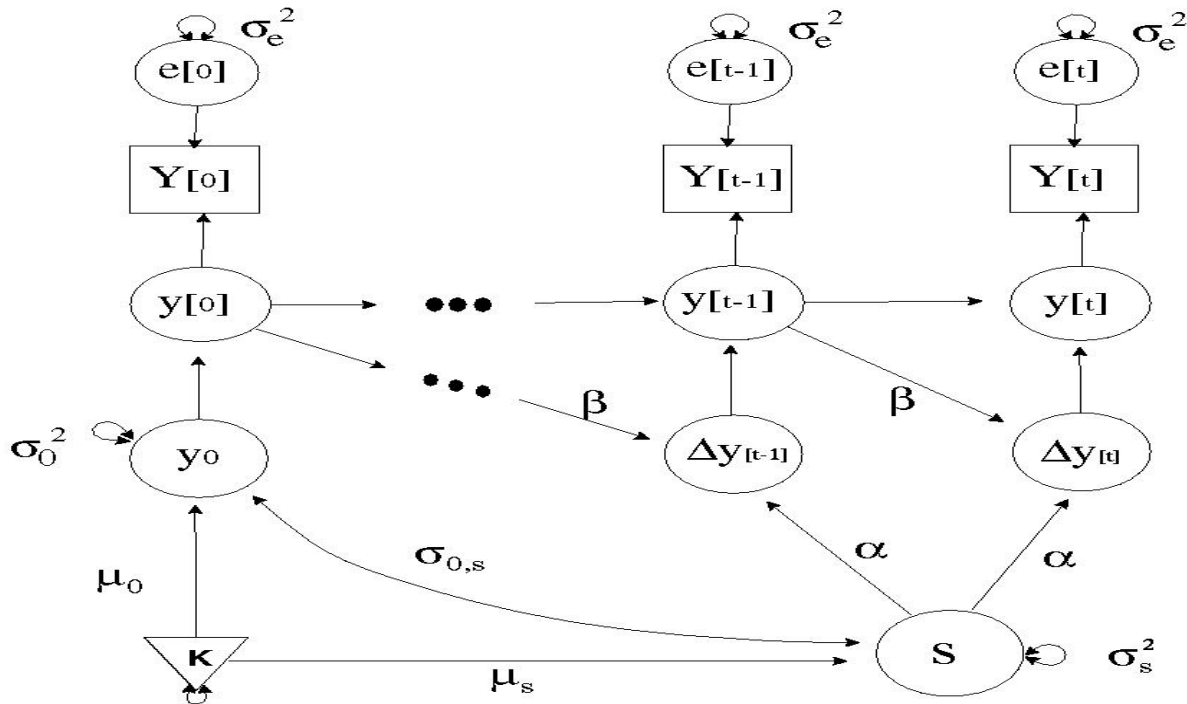
Alternative RCT based on SEM *(from McArdle & Prindle, 2008)*

Figure 3: A bivariate latent change score SEM
for a two variable Pre-Post analysis
(two-groups assumed, one one group displayed)



Our new logo –
from McArdle & Hamagami (2001, p. 143)

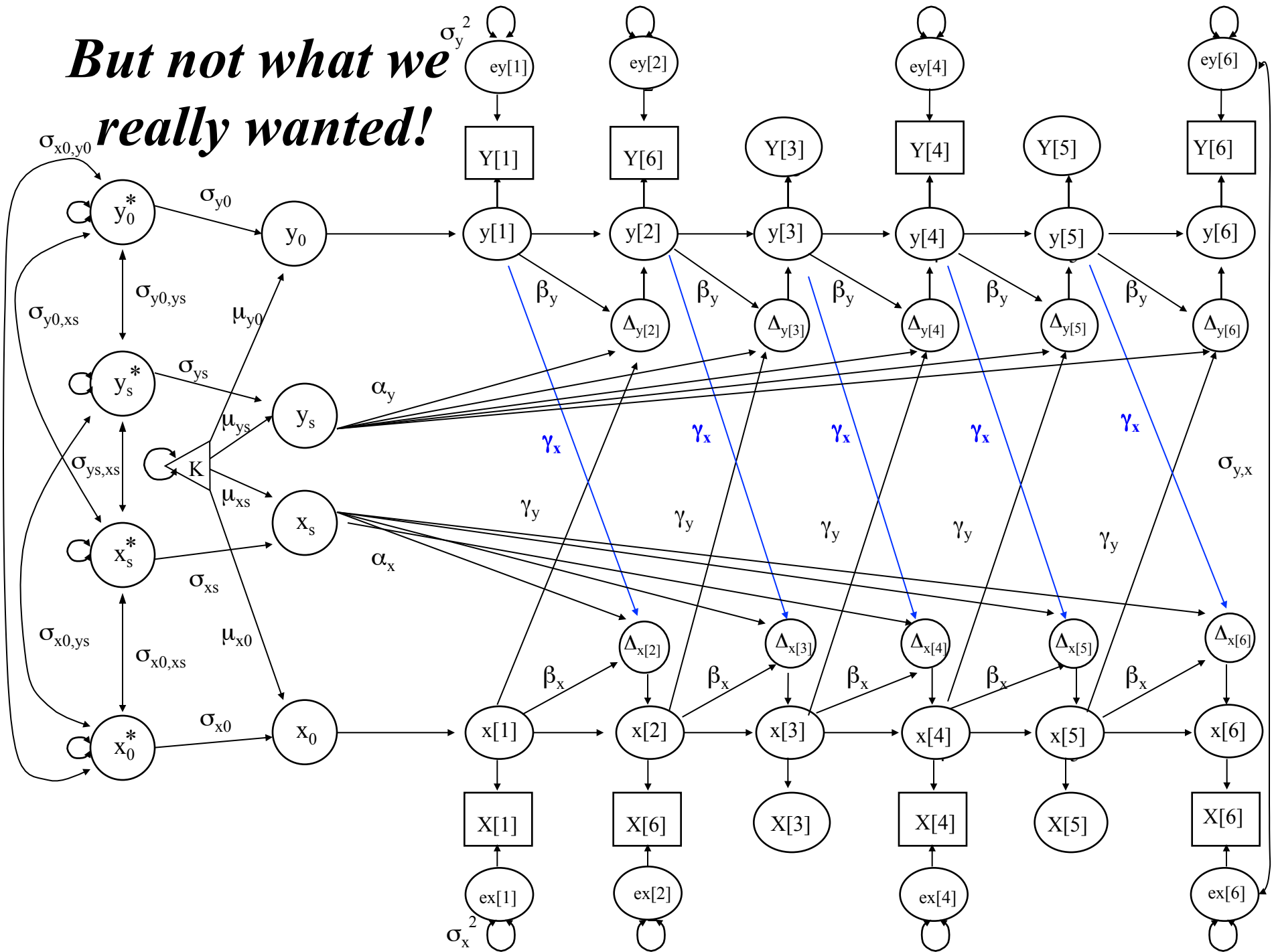
Figure 2: A latent variable path diagram of a Dual Change Score (DCS) model



Keys:

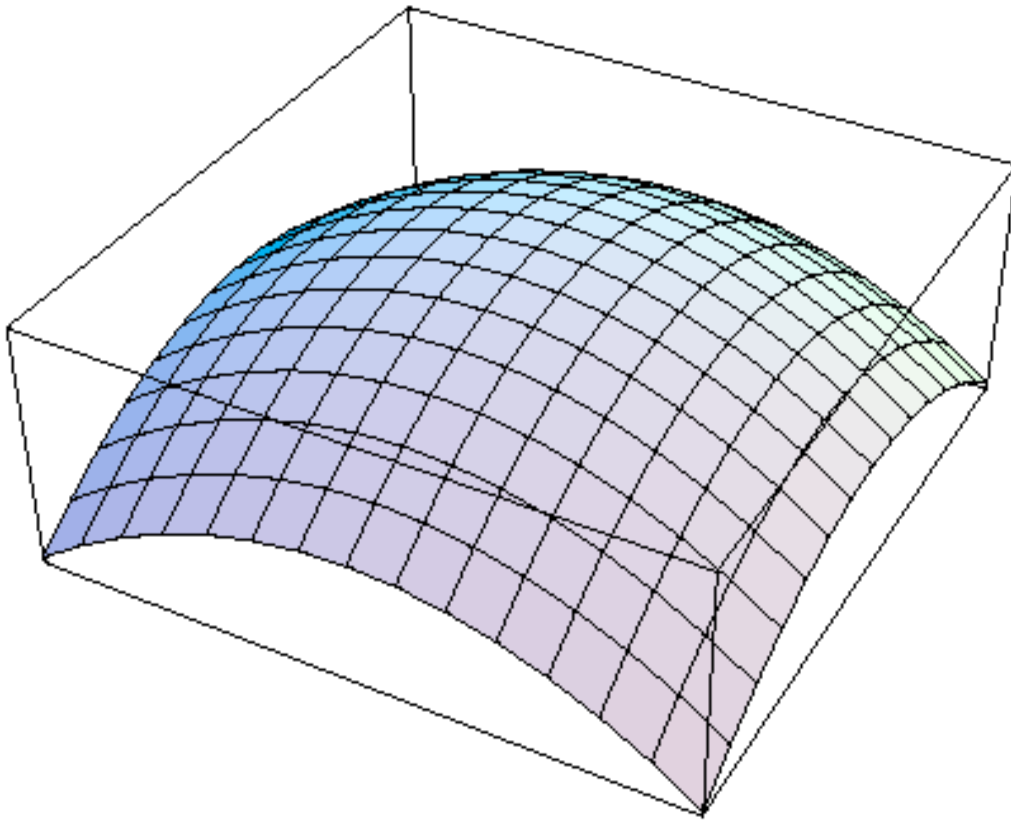
- Squares = observed variables
- Circles = latent variables
- △ Triangles = constants
- One-headed = regression coefficient
- ↔ Double-headed = correlation, covariance or cross-products
- Dots = an implied repetition of a time series

But not what we really wanted!

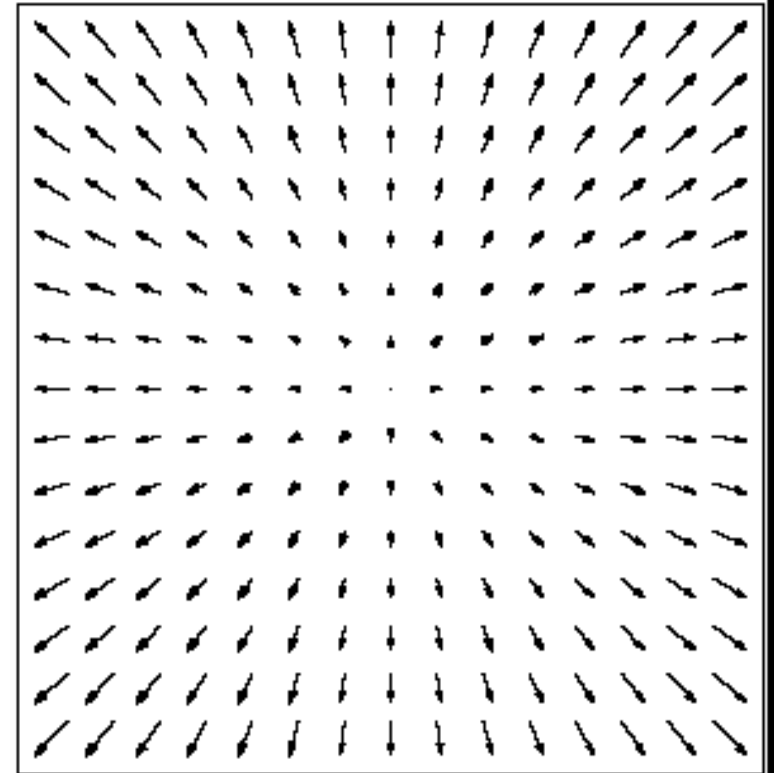


*Our most popular display –
Forecast Dynamics from a Vector Field*

a.)



b.)



Thanks to many others for their support

Thanks to the MPI-Berlin for holding the first McArdle & Nesselroade workshop in 1984.

Thanks to the APA Science Directorate for creating the challenging idea of an ATI in 2000.

Thanks to the last three years of LRI-USC students, faculty and staff for their valuable suggestions and invaluable support.

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