Application of Latent Change Score Models to Study Specific Changes

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Introduction

Motivation

- Latent growth curve models (LGCMs) examine the "average rate of change" over the entire study period. However, *change in a specific time interval* could be the actual research interest.
- Studying "specific change" can inform:
  - *Change in each time interval*
  - *When a substantial change occurs*
  - *How long the substantial change continues for*

Purpose of study

- To introduce the application of latent change score (LCS) model to examine:
  - Change from a previous time point
  - Change from the baseline (first time point)
  - Change from a particular time point of interest

Illustration with Depressive Symptoms Scale

Samples and measures

- 494 high school students in Vancouver
- The depressive symptoms scale (Bosworkth, Espelage, & Dahlberg, 1996)
- Outcome (range 1 to 5) was measured over 3 years

Research questions

- How had depressive symptoms changed from previous year?
- When did depressive symptoms show a substantial change from the baseline? And, how long had the change continued for?

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REFERENCES

- McArdle, J. J., & Hamagami, F. (2001). Latent difference score structural models for linear dynamic analyses with incomplete longitudinal data. In L. M. Collins & A. G. Sayer (Eds.), *New methods for the analysis of change* (pp. 139–175). Washington: American Psychological Association.
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A Proportional Change Model and its Extensions for Studying Specific Changes

Proportional Change Model, a type of LCS model (McArdle & Hamagami, 2001)

- LCS models examine a change based on latent difference scores. An individual's true score at each time point is modeled as a sum of previous true score and *the difference score (i.e., change)*.

$$Y_{ti} = Y_{(t-1)i} + \Delta Y_{ti}, \qquad (1)$$

where Y_{ti} is the true score at time *t* for individual *i*, $Y_{(t-1)i}$ is the true score at time *t-1* (i.e., previous time), and ΔY_{ti} is the latent difference score between time *t-1* and time *t*.

- *A proportional change model* addresses *interval specific difference scores* and is especially flexible for examining specific changes between time points.

Change from a previous time point to next time point

- A proportional change model shows a change for each time interval as follows:

$$\Delta Y_{ti} = \beta_{ti} * Y_{(t-1)i} \qquad (2)$$
$$Y_{ti} = Y_{(t-1)i} + \beta_{ti} * Y_{(t-1)i} \qquad (3)$$

$\boldsymbol{\Delta Y_{ti}}$ is the latent difference score between true scores at time *t* and its previous time point *t-1*. $\boldsymbol{\beta_{ti}}$ expresses the change as a proportion of previous true score.

Change from the baseline (first) time point to each time point

- The proportional change model can be extended to examine changes from the baseline by expressing true scores at time *t* as a sum of baseline and the difference between the baseline and time *t*:

$$\Delta Y_{ti} = \beta_{ti} * Y_{(baseline)i} \qquad (2a)$$
$$Y_{ti} = Y_{(baseline)i} + \beta_{ti} * Y_{(baseline)i} \qquad (3a)$$

$\boldsymbol{\Delta Y_{ti}}$ is the latent difference score between true scores at time *t* and the baseline. $\boldsymbol{\beta_{ti}}$ expresses the change as a proportion of baseline true score.

Change from a particular time point to each time point

- If the second time point is chosen as a meaningful reference, changes from the second time point can be examined by expressing true scores at time *t* as a sum of true score at the second time point and the difference between the second time point and time *t*:

$$\Delta Y_{ti} = \beta_{ti} * Y_{(second)i} \qquad (2b)$$
$$Y_{ti} = Y_{(second)i} + \beta_{ti} * Y_{(second)i} \qquad (3b)$$

$\boldsymbol{\Delta Y_{ti}}$ is the latent difference score between true scores at time *t* and the second time point. $\boldsymbol{\beta_{ti}}$ expresses the change as a proportion of second time point true score.

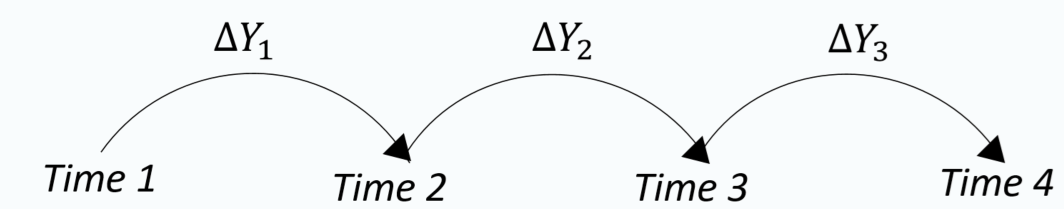

Figure 1. Changes from a Previous Time Point with 4 Waves

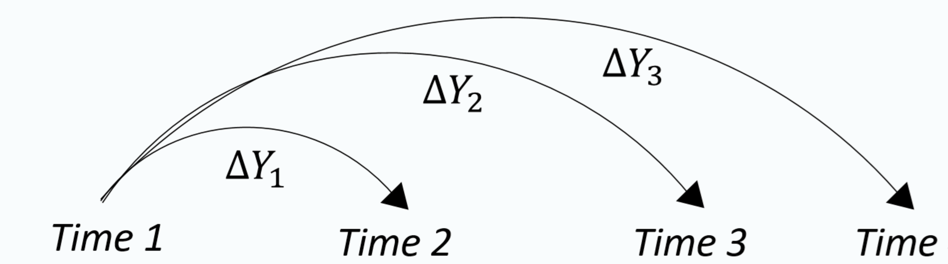

Figure 2. Changes from the Baseline with 4 Waves

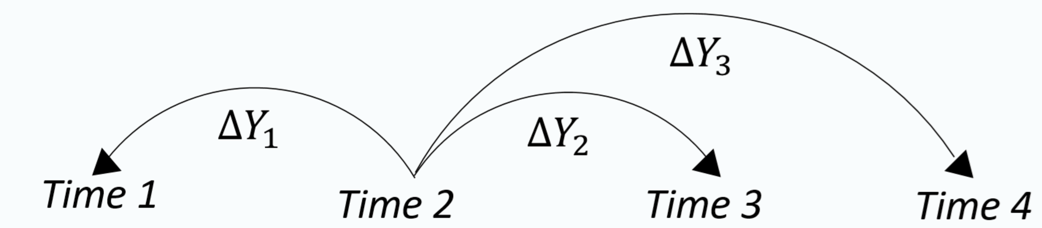

Figure 3. Changes from the Second Time point with 4 Waves

Results and Implication

Linear LGCM for average change (Table 1)

- The initial score of depressive symptoms was 2.72 and the score had increased by 0.09 points every year.

Proportional change model for change from a previous time point (Table 2)

- A 4% significantly increase in depressive symptoms from year 1 to year 2 ($\beta_1 = 0.04$) and a 2% non-significant increase from year 2 to year 3 ($\beta_2 = 0.02$)
- It implied that the scores of depressive symptoms increased the most between years 1 and 2, but remained stable afterwards.

Proportional change model for change from the baseline (Table 3)

- Depressive symptoms in years 2 and 3 were 4% and 6% significantly higher than the baseline (β_1 = 0.04 and $\beta_2 = 0.06$)
- This indicated that a significant change had occurred during the first time interval, and the change had continued in the following interval.

Table 1. LGCM for Average Change

	Estimate	p
Mean of initial status	2.72 (.03)	<.001
Mean of slope	.09 (.017)	<.001
Variance of initial status	.37 (.04)	<.001
Variance of slope	.05 (.02)	.003

Table 2. Change from Previous Time Point

	Estimate	p
Mean of first time point	2.71 (.03)	<.001
Variance of first time point	.30 (.02)	<.001
$\boldsymbol{\beta_1}$	.04 (.01)	<.001
$\boldsymbol{\beta_2}$	.02 (.01)	.064

Table 3. Changes from Baseline

	Estimate	p
Mean of initial status	2.71 (.03)	<.001
Variance of first time point	.30 (.02)	<.001
$\boldsymbol{\beta_1}$	.04 (.01)	<.001
$\boldsymbol{\beta_2}$	.06 (.01)	<.001

Discussion

- Studying specific changes in SEM framework has not been discussed often. The proportional change model and its extensions could serve this purpose.
- The proportional change models introduced in this study and LGCMs satisfy different research objectives. LGCMs are useful to understand "overall" trajectory across time.
- Although results in Table 2 and Table 3 appear very similar, it may not be always the case when the direction of change is inconsistent.