Longitudinal Research on Resilience

Fons J. R. van de Vijver

www.fonsvandevijver.org
Theme

• What can we learn about resilience by using longitudinal designs?
• Focus on recent developments in quantitative research methods to enhance the quality of our studies
  – No mixed methods studies discussed
• Challenge
  – Resilience is an interactive concept
  – Resilience influenced by
    • Personal resources
    • Contextual resources
    • Contextual challenges
    • ....
Relevance of Longitudinal Designs in Resilience Studies

- These designs can address many questions:
  - Resilience is a dynamic concept; longitudinal designs do justice to this idea
  - How does resilience develop over time?
  - Are there gender/age/ethnic differences in these patterns?
  - How important are personal and contextual (neighborhood, family) resources for the development of resilience?
  - How effective is a resilience intervention?
More generally, longitudinal designs can address two types of questions:

1. **“Level questions”**: change trajectories, change in mean scores,…

2. **“Structure questions”**: how is change related to personal and contextual conditions?
Structure Presentation

1. Methodological perspectives on change
   – Classical dilemmas
   – Modern solutions

2. Design and analysis of some recent longitudinal studies
   – Focus in presentation on examples
   – New perspective on change

3. Conclusions
Classical Dilemmas

• 1. Can change scores be used for analysis?
  – Change scores can be unreliable

• 2. What is responsible for changes over time?
  – Concept stays the same over time
    • Changes in height, weight
  – Concept changes over time
    • Changes in intelligence in first 10 years

• 3. Is dropout selective/random in longitudinal designs?
  – Do most/least resilient children drop out?
A Bit of History

• Focus was on repeated measures of the same (in)dependent variables

• Assessment of change often considered the Achilles heel of Classical Test Theory (Lord & Novick, 1968)

• Standard statistical procedures did not work well
  – Differences could be unreliable
  – Repeated measures ANOVA could not deal with missing values
  – Models often started from the assumption that growth follows an identical pattern for all participants
Unreliability of Difference Scores: A Paradox for Measurement of Change

John E. Overall and J. Arthur Woodward
University of Texas Medical Branch, Galveston

HOW WE SHOULD MEASURE "CHANGE"—OR SHOULD WE?!?

LEE J. CRONBACH² AND LITA FURBY³
Stanford University

Procedures previously recommended by various authors for the estimation of "change" scores, "residual" or "basefree" measures of change, and other kinds of difference scores are examined. A procedure proposed by Lord is extended to obtain more precise estimates, and an alternative to the Tucker-Damarin-Messick procedure is offered. A consideration of the purposes for which change measures have been sought in the past leads to a series of recommended procedures which solve research and personnel-decision problems without estimation of change scores for individuals.
Modern solutions

• Rigidity of conventional approach did not work
  – Change assessment is vital in many areas of psychology, sociology, community development, ...

• In the last 30 years there has been a spectacular increase in available models and procedures for longitudinal data analysis
  – Now available for all measurement levels
• Major advances in missing value analysis and imputation (source: Wikipedia)
  – MCAR
    • Values in a data set are missing completely at random (MCAR) if the events that lead to any particular data-item being missing are independent both of observable variables and of unobservable parameters of interest, and occur entirely at random.
  – MAR
    • occurs when the missingness is related to a particular variable, but it is not related to the value of the variable that has missing data.
  – MNAR
    • data missing for a specific reason (e.g., deliberate item skipping)
• Statistical tests of MCAR available
• Dealing with missingness under MCAR and MAR
  – Imputation of missing data that are MCAR or MAR can be done
  – Procedures in Structural Equation Modeling packages available for working with missing data under MCAR and MAR
Example Longitudinal Resilience Study

- Kauai Longitudinal Study (Werner & Smith, 2001)
  - Longitudinal study from infancy to adulthood
    - identify key risk and protective factors that influence resilience outcomes
  - Outcomes were influenced by
    - (1) **individual characteristics**, such as self-esteem
    - (2) **characteristics of families**, such as maternal caregiving
    - (3) **larger social context**, especially having supportive adult role models
  - Conclusion:
    - Longitudinal study of resilience should include change at multiple levels
Part 1
Design and Analysis of Some Recent Longitudinal Studies
Size at birth and resilience to effects of poor living conditions in adult life: longitudinal study

D J P Barker, T Forsén, A Uutela, C Osmond, J G Eriksson

BMJ VOLUME 323 1 DECEMBER 2001 bmj.com
• Topic: Size at birth and resilience to effects of poor living conditions in adult life in Finland
• Sample: Participants 3676 men
  – born during 1934-1944
  – Attended child welfare clinics in Helsinki
• Setting: Helsinki, Finland
• Predictors
  – Income
  – Education
  – SES in infancy and adult life
• Outcome
  – Hospital admission for or death from coronary heart disease between 1971 and 1997
• Analyses
  – Ratio of hazard (related to probability of coronary heart disease) to non-hazard is analyzed
  – Hazard ratios predicted by background variables

• Results
  – Hazard increases as a function of each independent variable in a predictable manner
• Methodological notes
  – Different variables measured at different time points; change does not need to be modeled
  – Regression analysis (modeling hazard ratios) to predict outcomes
  – Not all members of original cohort could be followed
    • Selectivity of dropout?
      – Very often a problem; infrequently addressed
Second Example

RAND D. CONGER AND KATHERINE J. CONGER
University of California—Davis

Resilience in Midwestern Families: Selected Findings from the First Decade of a Prospective, Longitudinal Study

Journal of Marriage and Family 64 (May 2002): 361-373
• Panel study 1989-1993 (yearly)
• Setting: rural Iowa; severe economic downturn in the 1980s
Figure 1. The Family Stress Model of Economic Hardship Incorporating Resilience Promoting Social and Personal Resources

Note: Dashed arrows from resources indicate statistical main or compensatory effects and completed arrows from resources indicate statistical interaction, moderating, or buffering effects.
• Focus here on parental sense of mastery/control as a resource
Role of Parenting

1. High nurturant - involved parenting: Mothers above, Fathers below

   - Older Sibling Alcohol Use-Abuse to Younger Sibling Alcohol Use-Abuse
     - .23 (n.s.)
     - .13 (n.s.)

2. Low nurturant - involved parenting: Mothers above, Fathers below

   - Older Sibling Alcohol Use-Abuse to Younger Sibling Alcohol Use-Abuse
     - .40*
     - .43*
• Methodological notes
  – Analysis of change scores in path analysis
    • Can be problematic for methodological reasons
  – Type of parenting as moderator
    • Test of similarity of regression coefficients
    • Multigroup analysis in Structural Equation Modeling
Looking for resilience: Understanding the longitudinal trajectories of responses to stress

Fran H. Norris\textsuperscript{a,\ast}, Melissa Tracy\textsuperscript{b}, Sandro Galea\textsuperscript{b}

\textsuperscript{a}Dartmouth Medical School, Psychiatry/NCPTSD, VA Medical Center, 215 North Main Street, White River Junction, VT 05009, USA
\textsuperscript{b}University of Michigan, MI, USA
• Time trajectory of coping with stress in Mexico (two sites, after floods) and in New York (after 9/11)
• Assessment: Mexico (n = 561)
• PTSD was measured by using a modified version of Module K of Version 2.1 of the Composite International Diagnostic Interview (CIDI)
• 2001 terrorist attacks in New York (n = 1267)
• National Women’s Study (NWS) posttraumatic stress module questions to assess PTSD

• Instruments in both studies ask about symptom prevalence
Hypothesized Coping Patterns

**Fig. 1.** Hypothesized trajectories of the course of stress responses.
• Analyses:
  – main interest in symptom trajectories
• “Manual” split in different subgroups
  – Trajectories per subgroup
• Zero inflated regression per subgroup (zero inflated to account for many people without symptoms)
Fig. 2. Trajectories of PTSD symptoms among residents of Villahermosa and Teziutlán in Mexico (n = 561) after the 1999 flood. Numbers in parentheses refer to the wave of assessment.
<table>
<thead>
<tr>
<th>Group</th>
<th>Symptom trajectory&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Parameter</th>
<th>Estimate (SE)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>p-Value</th>
<th>Prevalence</th>
<th>Mean posterior probability (SD)&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stable, mild</td>
<td>Intercept</td>
<td>2.308 (0.161)</td>
<td>&lt;0.001</td>
<td>34.5%</td>
<td>0.926 (0.133)</td>
</tr>
<tr>
<td>2</td>
<td>Stable, moderate</td>
<td>Intercept</td>
<td>6.881 (0.699)</td>
<td>&lt;0.001</td>
<td>12.0%</td>
<td>0.702 (0.163)</td>
</tr>
<tr>
<td>3</td>
<td>Decreasing, severe (1) to moderate (2)</td>
<td>Intercept</td>
<td>17.686 (0.991)</td>
<td>&lt;0.001</td>
<td>32.0%</td>
<td>0.821 (0.180)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear</td>
<td>-1.453 (0.130)</td>
<td>&lt;0.001</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quadratic</td>
<td>0.036 (0.004)</td>
<td>&lt;0.001</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>4</td>
<td>Decreasing, severe (1) to moderate (4)</td>
<td>Intercept</td>
<td>15.377 (1.355)</td>
<td>&lt;0.001</td>
<td>11.4%</td>
<td>0.818 (0.146)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear</td>
<td>-0.343 (0.079)</td>
<td>&lt;0.001</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>5</td>
<td>Stable, severe</td>
<td>Intercept</td>
<td>12.343 (0.393)</td>
<td>&lt;0.001</td>
<td>10.0%</td>
<td>0.827 (0.161)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Mild: 0–3 symptoms; moderate: 4–8 symptoms; severe: ≥9 symptoms; numbers in parentheses indicate survey wave.

<sup>b</sup> Standard error.

<sup>c</sup> Standard deviation.

Table 1: Parameter estimates, prevalence, and mean posterior probability of assignment for each PTSD symptoms trajectory group among residents of Villahermosa and Teziutlán in Mexico (n = 561) after the 1999 flood.
Fig. 3. Trajectories of PTSD symptoms among residents of the New York City metropolitan area (n = 1,267) after the September 11, 2001 attacks. Numbers in parentheses refer to the wave of assessment.
<table>
<thead>
<tr>
<th>Group</th>
<th>Symptom trajectory&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Parameter</th>
<th>Estimate (SE)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>p-Value</th>
<th>Prevalence</th>
<th>Mean posterior probability (SD)&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stable, mild</td>
<td>Intercept</td>
<td>-1.847 (0.174)</td>
<td>&lt;0.001</td>
<td>40.1%</td>
<td>0.921 (0.135)</td>
</tr>
<tr>
<td>2</td>
<td>Increasing, mild (1) to mild (2)</td>
<td>Intercept</td>
<td>-7.617 (3.239)</td>
<td>0.019</td>
<td>13.3%</td>
<td>0.806 (0.179)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear</td>
<td>1.08 (0.433)</td>
<td>0.011</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quadratic</td>
<td>-0.044 (0.016)</td>
<td>0.006</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cubic</td>
<td>0.001 (0.0002)</td>
<td>0.003</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>3</td>
<td>Decreasing, moderate (1) to mild (2)</td>
<td>Intercept</td>
<td>3.210 (0.573)</td>
<td>&lt;0.001</td>
<td>10.1%</td>
<td>0.834 (0.175)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear</td>
<td>-0.291 (0.066)</td>
<td>&lt;0.001</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quadratic</td>
<td>0.004 (0.001)</td>
<td>&lt;0.001</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>4</td>
<td>Increasing, mild (1) to moderate (4)</td>
<td>Intercept</td>
<td>2.360 (0.812)</td>
<td>0.004</td>
<td>14.3%</td>
<td>0.829 (0.175)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear</td>
<td>-0.335 (0.133)</td>
<td>0.011</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quadratic</td>
<td>0.015 (0.006)</td>
<td>0.015</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cubic</td>
<td>-0.0002 (0.00008)</td>
<td>0.029</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>5</td>
<td>Increasing, moderate (1) to moderate (4)</td>
<td>Intercept</td>
<td>0.320 (0.504)</td>
<td>0.525</td>
<td>9.9%</td>
<td>0.878 (0.139)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear</td>
<td>0.195 (0.056)</td>
<td>0.001</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quadratic</td>
<td>-0.007 (0.002)</td>
<td>0.001</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cubic</td>
<td>0.000009 (0.00003)</td>
<td>0.001</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>6</td>
<td>Decreasing, moderate (1) to mild (4)</td>
<td>Intercept</td>
<td>0.885 (0.305)</td>
<td>0.004</td>
<td>9.3%</td>
<td>0.862 (0.152)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear</td>
<td>0.079 (0.025)</td>
<td>0.001</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quadratic</td>
<td>-0.002 (0.001)</td>
<td>&lt;0.001</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>7</td>
<td>Stable, severe</td>
<td>Intercept</td>
<td>2.049 (0.215)</td>
<td>&lt;0.001</td>
<td>3.1%</td>
<td>0.937 (0.104)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear</td>
<td>0.039 (0.015)</td>
<td>0.008</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quadratic</td>
<td>-0.001 (0.0002)</td>
<td>0.002</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

<sup>a</sup> Mild: 0–3 symptoms; moderate: 4–8 symptoms; severe: ≥ 9 symptoms; numbers in parentheses indicate survey wave.

<sup>b</sup> Standard error.

<sup>c</sup> Standard deviation.
• Methodological notes
  – Unclear why latent class analysis was not applied; now possible to combine latent class and regression analysis
Family Adversity, Positive Peer Relationships, and Children’s Externalizing Behavior: A Longitudinal Perspective on Risk and Resilience

Michael M. Criss, Gregory S. Pettit, John E. Bates, Kenneth A. Dodge, and Amie L. Lapp
• Site: Families with children entering kindergarten were recruited from two cohorts in 1987 and 1988 from three sites: Knoxville and Nashville, Tennessee and Bloomington, Indiana
• Data collected in two consecutive years
• Risk factors were assessed in interviews
  – three measures of family adversity: ecological disadvantage (e.g., low SES), violent marital conflict, and harsh discipline
• Moderators:
  – Peer ratings of acceptance (liked and disliked peers)
  – Ethnicity
  – Gender
  – Temperament (rating by mother)

• Outcome measured after one year
  – child's teacher completed the 112-item Child Behavior Checklist-Teacher Report Form (CBCL-TRF; Achenbach, 1991) → externalizing behavior
• Analysis
  – Stepwise regression, with moderators entered as interactions
  – E.g., can positive peer relations help to overcome ecological hardship?
  – Tw-step regression
    • Step 1: positive peer relations and ecological hardship
    • Step 2: interaction (multiplication of centered independent variables) added
      – Moderation if interaction is significant
Table 3  Regressions Examining Positive Peer Relationships as Moderators in the Link between Family Adversity and Children's Externalizing Behavior

<table>
<thead>
<tr>
<th>Step</th>
<th>Predictor</th>
<th>Peer Acceptance</th>
<th></th>
<th></th>
<th>Friendships</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Standardized β</td>
<td>ΔR²</td>
<td>Standardized β</td>
<td>ΔR²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Ecological Disadvantage</td>
<td>.22***</td>
<td>.22***</td>
<td>.28***</td>
<td>.13***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Positive Peer Relationship</td>
<td>−.37***</td>
<td></td>
<td></td>
<td>−.19***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Ecological Disadvantage × Peer Relationship</td>
<td>−.12**</td>
<td>.01**</td>
<td></td>
<td>.05</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Violent Marital Conflict</td>
<td>.14**</td>
<td>.16***</td>
<td>.17***</td>
<td>.07***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Positive Peer Relationship</td>
<td>−.36***</td>
<td></td>
<td></td>
<td>−.19***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Marital Conflict × Peer Relationship</td>
<td>−.17***</td>
<td>.02***</td>
<td></td>
<td>−.05</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Harsh Discipline</td>
<td>.09*</td>
<td>.18***</td>
<td>.17***</td>
<td>.07***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Positive Peer Relationship</td>
<td>−.40***</td>
<td></td>
<td></td>
<td>−.21***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Harsh Discipline × Peer Relationship</td>
<td>−.08*</td>
<td>.01*</td>
<td></td>
<td>−.09*</td>
<td>.01*</td>
<td></td>
</tr>
</tbody>
</table>

Note: Ns = 449 to 517.

*p < .05; ** p < .01; *** p < .001.
## Table 4 Regression Slopes Depicting the Association between Family Adversity and Children’s Externalizing Behavior at Different Levels of Positive Peer Relationship

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Predictor</th>
<th>Levels of Positive Peer Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological disadv.</td>
<td>Peer acceptance</td>
<td>.92</td>
</tr>
<tr>
<td>Violent marital conflict</td>
<td>Peer acceptance</td>
<td>2.27***</td>
</tr>
<tr>
<td>Harsh discipline</td>
<td>Peer acceptance</td>
<td>3.62***</td>
</tr>
<tr>
<td>Harsh discipline</td>
<td>Peer acceptance</td>
<td>−1.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.03***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.10*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.10**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.99</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.97***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.94***</td>
</tr>
</tbody>
</table>

* *p < .05; ** *p < .01; *** *p < .001.
• Methodological notes
  – Focus on individual-level moderators
  – Stepwise regression used to examine the role of moderators
    • SPSS + specific routines available to estimate significance
  – Alternative
    • Structural equation modeling
      – Split up in groups with different levels of moderator and test invariance of model
      – Suitable in particular for nominal moderators such as gender and ethnicity
  – Caveat
    • Estimate proportion of variance accounted for by moderator (significance may not imply salience)
New Perspective on Change
Latent Growth Analysis

(Hox, 2000)
Example

• Clark, Diener et al. (2008), *The Economic Journal*
• German Panel Data (1984-2003), N = 16,795
• Life satisfaction after
  – unemployment
  – layoff
  – marriage
  – divorce
  – death of spouse
  – birth of child
Marriage

No. of years before and after the event
Psychopathology and Resilience Following Traumatic Injury:
A Latent Growth Mixture Model Analysis

Terri A. deRoon-Cassini
Medical College of Wisconsin

Anthony D. Mancini
Pace University

Mark D. Rusch
Medical College of Wisconsin

George A. Bonanno
Columbia University
• A longitudinal study of 330 injured trauma survivors (mostly car accidents)
• Assessed during hospitalization, and at 1, 3, and 6 months follow-up.
• Instruments
  – Acute Stress Disorder Interview (ASD-I)
  – Post-Traumatic Stress Diagnostic Scale (PDS)
  – Center for Epidemiologic Studies Depression Scale (CESDS).
Identified four latent classes
  – chronic distress
  – delayed distress
  – recovered
  – Resilience (low stress)
Figure 1. Four-class solution for PTSD symptoms (includes covariates).
Figure 2. Four-class solution for depression symptoms (includes covariates).
Table 6

*Covariates Prediction of Trajectory Class Membership: Depression*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Delayed</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
<td>OR</td>
<td>95% CI</td>
<td>OR</td>
</tr>
<tr>
<td>Human intention</td>
<td>2.06†</td>
<td>.40–12.56</td>
<td>5.59</td>
<td>.59–53.01</td>
<td>6.42*</td>
</tr>
<tr>
<td>Education</td>
<td>.83†</td>
<td>.66–1.03</td>
<td>.81</td>
<td>.56–1.17</td>
<td>.80†</td>
</tr>
<tr>
<td>Self-efficacy T1</td>
<td>1.04</td>
<td>.74–1.45</td>
<td>.68</td>
<td>.40–1.14</td>
<td>.62*</td>
</tr>
<tr>
<td>Anger T1</td>
<td>1.16*</td>
<td>1.03–1.32</td>
<td>1.15†</td>
<td>.98–1.35</td>
<td>1.22*</td>
</tr>
</tbody>
</table>

*Note.* Low symptom class served as the referent. OR = odds ratio; CI = confidence interval; T1 = baseline. 

a 1 = human intention; 0 = accident.

† = $p < .10$. * = $p < .05$. 
• Study combines analysis of
  – Mean changes across time
  – Latent classes
  – Predictors of change
Part 3
Conclusions
• Many procedures developed in the last decades, both level- and structure-oriented
• Procedures often do not use change scores but model change as a function of original scores
• What is the best procedure will vary across studies
Future

- No models yet of systemic change at multiple levels (interrelated changes in child, family, community)
- Change from relatively few time points to multiple time points (collecting “big data” using modern technology)
  - Following an intervention program using Facebook, Twitter, local media, dedicated apps, ...