Considerations in Selecting Amongst Alternative Metrics of Time

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Goals of Longitudinal* Modeling

- 5 rationales of longitudinal research
  - Baltes & Nesselroade, 1979
    - Chapter 1: *Longitudinal Research in the Study of Behavior and Development*
- 7 levels of longitudinal analysis
  - Hofer & Sliwinski, 2006
    - Chapter 2: *Handbook of the Psychology of Aging (6th edition)*
- 7+ steps in longitudinal modeling
  - Singer & Willett, 2003
    - Chapter 4: *Applied Longitudinal Data Analysis*

*Applicable to both the MLM and SEM analytic frameworks

Steps in Longitudinal Analysis

1. Decompose **BP and WP variation**—Intraclass Correlation
   - **ICC** = proportion of outcome variance that is *constant* over time, and that results from *cross-sectional* differences

3. Describe pattern of average change over time **(fixed effects)** and individual differences therein **(random effects)**
   - Piecewise slopes models—Phases of discontinuous change
   - Polynomial models—Approximate nonlinear continuous change
   - Truly nonlinear models—Exponential or logistic change
   - Latent basis models—Estimate shape of nonlinear change

Steps in Longitudinal Analysis

4. Predict **inter-individual differences** in change
   - *Why do people need their own intercepts and slopes?*

5. Predict **intra-individual variation** from predicted change
   - *Why are you off your line today (time-specific influences)?*

6. Examine **multivariate relationships**
   - *Between-person correlations among intercepts and slopes*
   - *Within-person covariation of residuals (or lead-lag associations)*

7. Examine other sources of underlying **heterogeneity**
   - *Mixture models for discrete types of individual differences*
   - *Predict individual differences in within-person variability*

Road Map

- Steps in longitudinal analysis
- **The missing step #2**
- Example: Alternative metrics of “time”
- What about just time?
- What else contributes to “time”?

The Missing Step 2

- **Summary across steps**: The goal of creating statistical models of change is to describe the overall pattern of and predict individual differences in **change over time**.

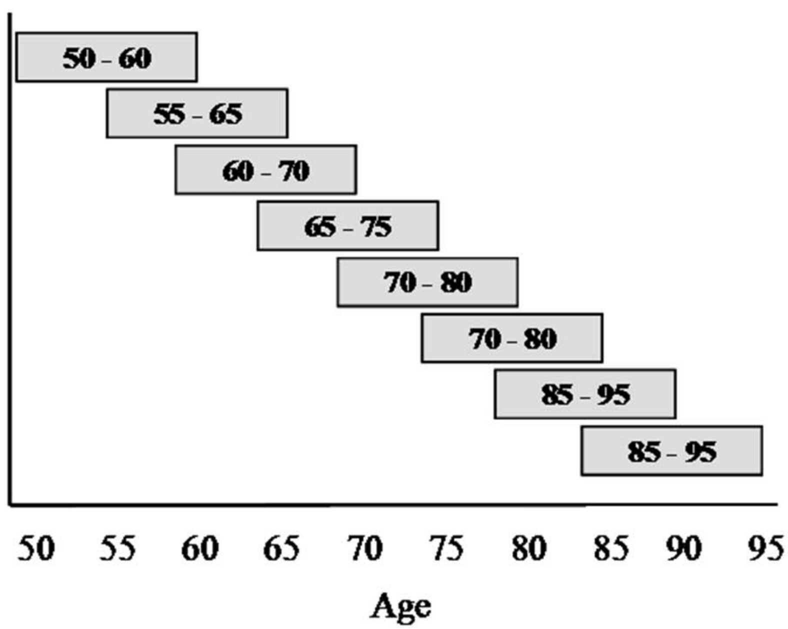
- These models employ an often unrecognized assumption **that we know exactly what "time" should be**.

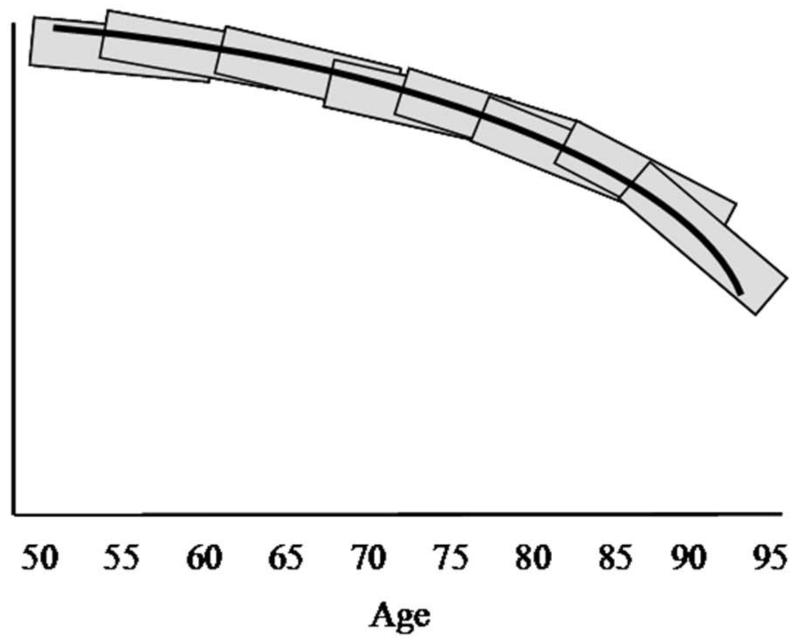
- So the missing Step 2 is a pre-cursor to every other step in longitudinal analysis, and involves 2 related concerns:
  - **What should "time" be?**
  - **How should "time" be modeled when people differ in "time"?**
  - Concerns apply specifically to *accelerated longitudinal designs*

Accelerated Longitudinal Designs

Want to do a longitudinal study but just don't have the time?

Accelerate: Model trajectories over a wider span of time than would be possible using only the observed longitudinal info…





The Missing Step 2

- **First: What should "time" be?**
  - Which **metric of time** best matches the **causal process** thought to be responsible for observed change?
  - Do **alternative metrics of time** for **multiple processes** create different pictures of change and individual differences therein?
  - Relevant for aligning different persons onto same time trajectory, but this distinction is **not relevant within persons**

- **Second: What do we do when people differ in "time"?**
  - **How should "time" be modeled in accelerated designs?**
  - When people begin a study at different points in time, how should we distinguish effects of ***between-person differences*** in time from effects of ***within-person changes*** in time?

Road Map

- Steps in longitudinal analysis
- The missing step #2
- **Example: Alternative metrics of "time"**
- What about just time?
- What else contributes to "time"?

Example Data:
Octogenarian (Twin) Study of Aging

- **173 persons (65% women)**
  - Measured up to **5 occasions** over 8 years
  - **Known** dates of birth and death
  - **Estimated** dates of dementia diagnosis (91 Alz., 50 Vas., 32 Mixed)

Correlation	Age	Death
Death	.23	
Dementia	.17	.52

- **Baseline occasion "time" variability:**
  - 79 to 100 years of age (M = 84, SD = 3)
  - −16 to 0 years from death (M = −6, SD = 4)
  - −12 to 18 years from diagnosis (M = 0, SD = 5)

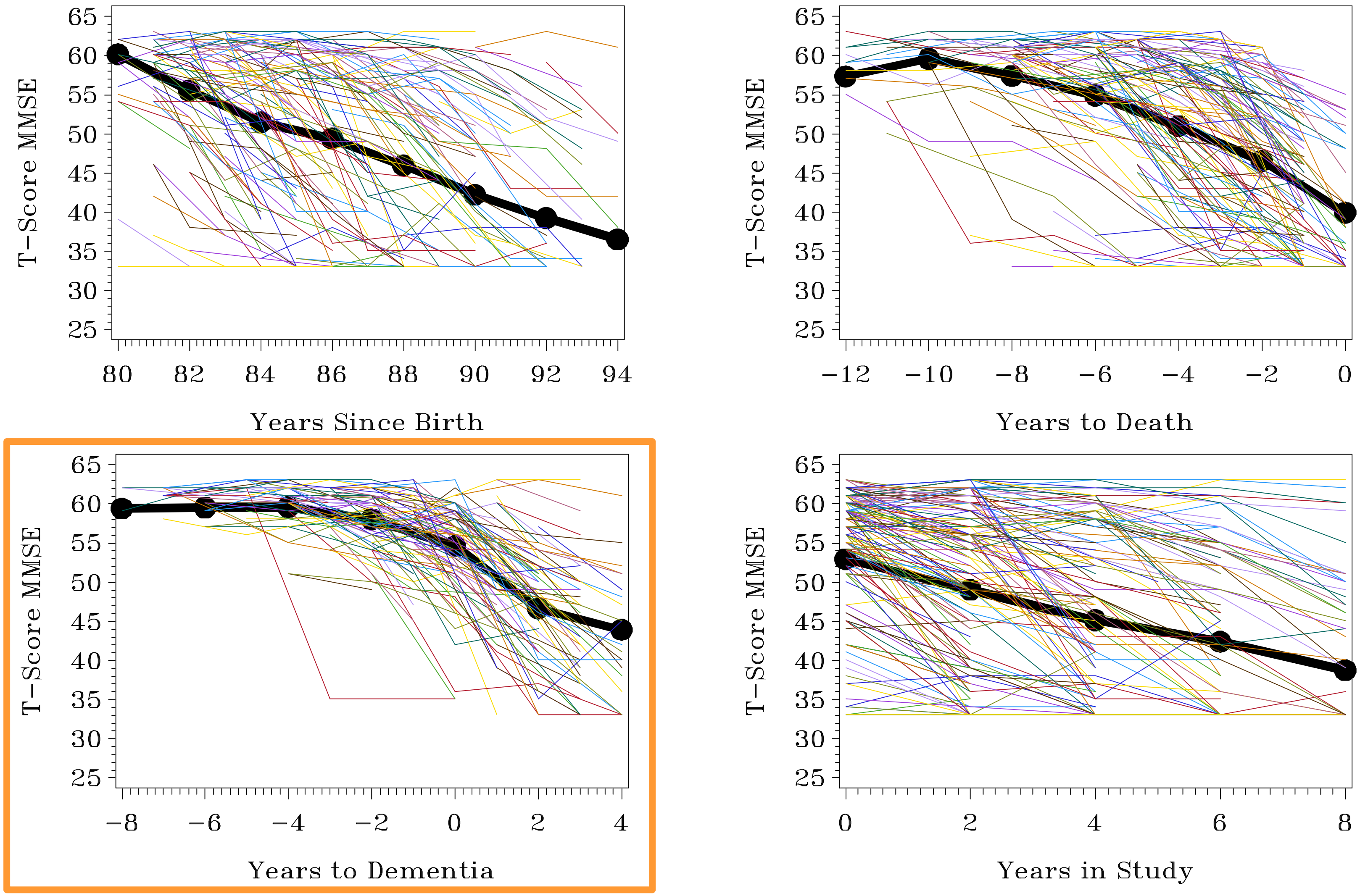
- **Cognition outcomes (each T-scored):**
  - General: Mini-Mental Status Exam
  - Memory: Object Recall
  - Spatial Reasoning: Block Design

#Persons per #Occasions				
1	**2**	**3**	**4**	**5**
28	37	36	36	35
29	31	39	29	18
37	32	31	22	19

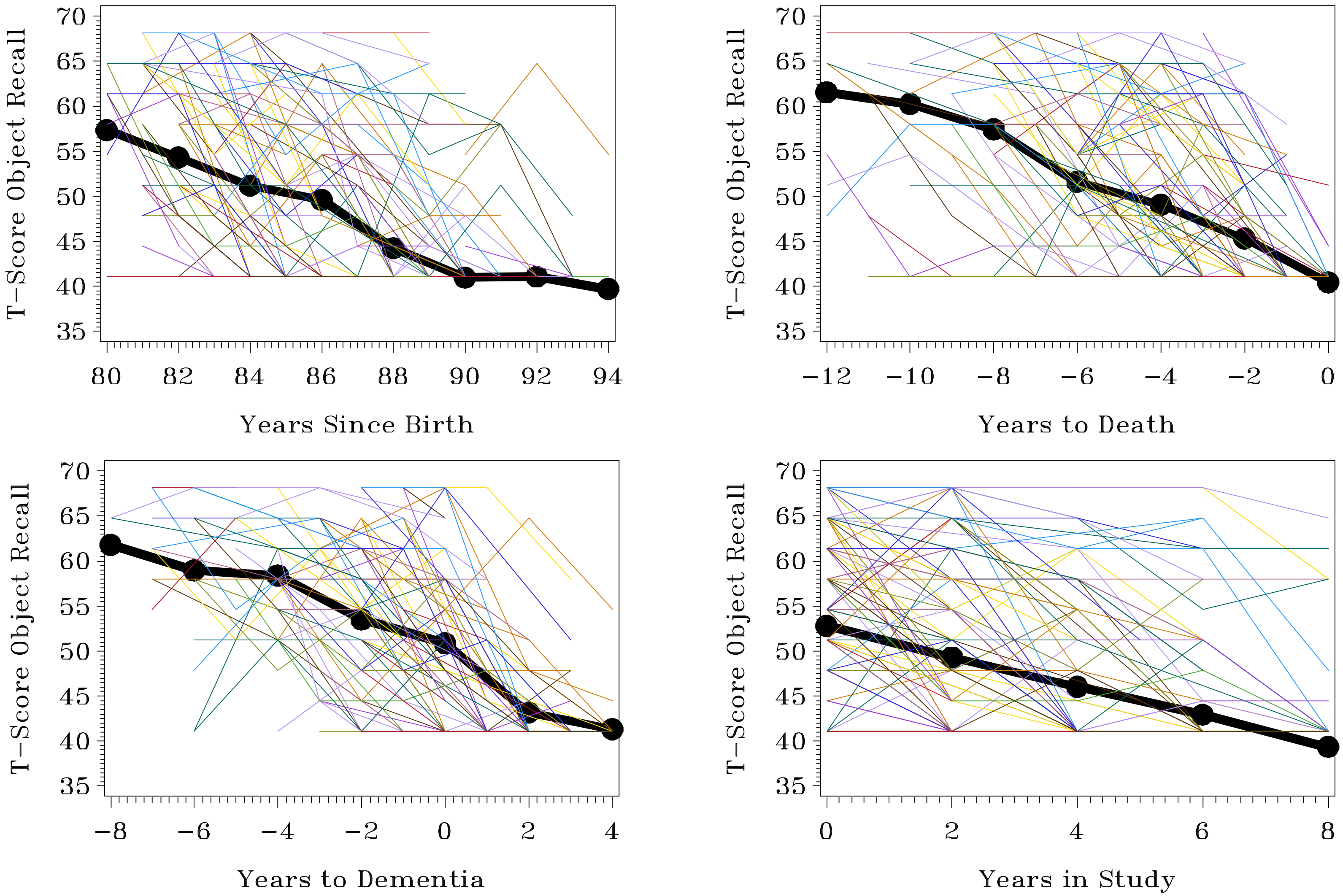
Alternative Metrics of Time (and ICC)

- Chronological Age as Time (47% BP)
  - Individual differences are organized around the mean level for a given **distance from birth** (84 years) and change with distance from birth
- Years to Death as Time (24% BP)
  - Individual differences are organized around the mean level for a given **distance from death** (−7 years) and change with distance from death
- Years to Dementia Diagnosis as Time (70% BP)
  - Individual differences are organized around the mean level for a given **distance from diagnosis** (=0) and change with distance from diagnosis
- Years in Study as Time (0% BP)
  - Individual differences are organized around the mean level for a given **distance from baseline** (=0) and change with distance from baseline

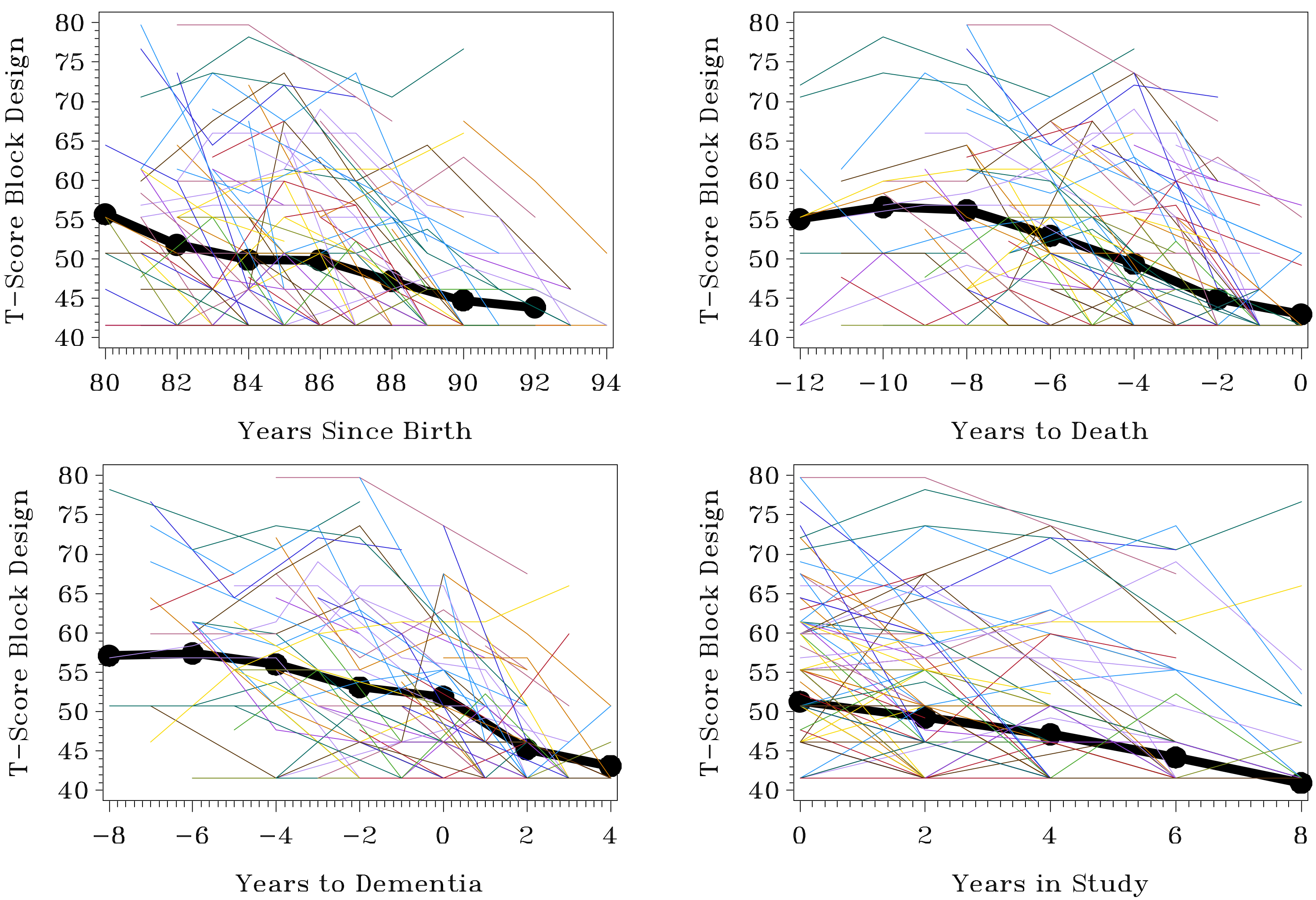
General Cognition: MMSE



Memory: Object Recall



Spatial Reasoning: Block Design



First Option: Age-as-Time

Level-1: $y_{ti} = \beta_{0i} + \beta_{1i}(Age_{ti}-84) + \beta_{2i}(Age_{ti}-84)^2 + e_{ti}$

Level-2 Equations → Fixed and Random Effects:

$\beta_{0i} = \gamma_{00} + U_{0i}$ → predicted Y when age=84

- β_{0i}: **Intercept** for person *i*
- γ_{00}: Fixed **Intercept** (mean)
- U_{0i}: Random **Intercept** Deviation

$\beta_{1i} = \gamma_{10} + U_{1i}$ → rate of Δ when age=84

- β_{1i}: **Linear Slope** for person *i*
- γ_{10}: Fixed **Linear Slope** (mean)
- U_{1i}: Random **Linear Slope** Deviation

$\beta_{2i} = \gamma_{20} + U_{2i}$ → ½ rate of Δ in Δ per year

- β_{2i}: **Quad Slope** for person *i*
- γ_{20}: Fixed **Quad Slope** (mean)
- U_{2i}: Random **Quad Slope** Deviation

First Option: Age-as-Time

- If people differ in initial age, measuring change as a function of age requires assuming **age convergence:**
  - Younger people and older people differ *only* by age
  - Effects of between-person, **cross-sectional age differences** are equivalent to effects of within-person, **longitudinal age changes**
- Age convergence is not likely to hold when:
  - Initial **age range** is large (47% of age is BP here)
  - **Cohort** differences and **selection** effects are large
- Is exactly the same problem as not fully separating the BP and WP effects of **ANY** time-varying predictor
  - *i.e., conflated, convergence, composite, or smushed effect*

Examining Age Convergence Effects

Can use a variant of **grand-mean-centering** to test equivalence of BP and WP age effects empirically

Level-1 **Age-Based** Change:

$$y_{ti} = \beta_{0i} + \beta_{1i}(Age_{ti} - 84) + \beta_{2i}(Age_{ti} - 84)^2 + e_{ti}$$

Level-2 Equations:

$$\beta_{0i} = \gamma_{00} + \gamma_{01}(AgeT1_i - 84) + U_{0i}$$

$$\beta_{1i} = \gamma_{10} + \gamma_{11}(AgeT1_i - 84) + U_{1i}$$

$$\beta_{2i} = \gamma_{20} + \gamma_{21}(AgeT1_i - 84) + U_{2i}$$

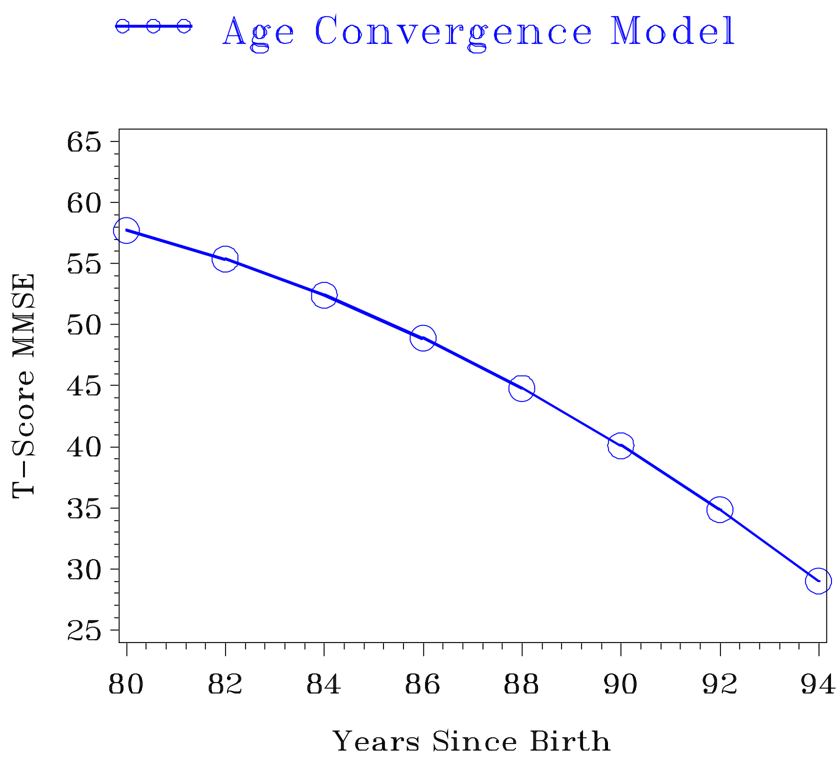
AgeT1 → Incremental effect of cross-sectional age (**cohort**)

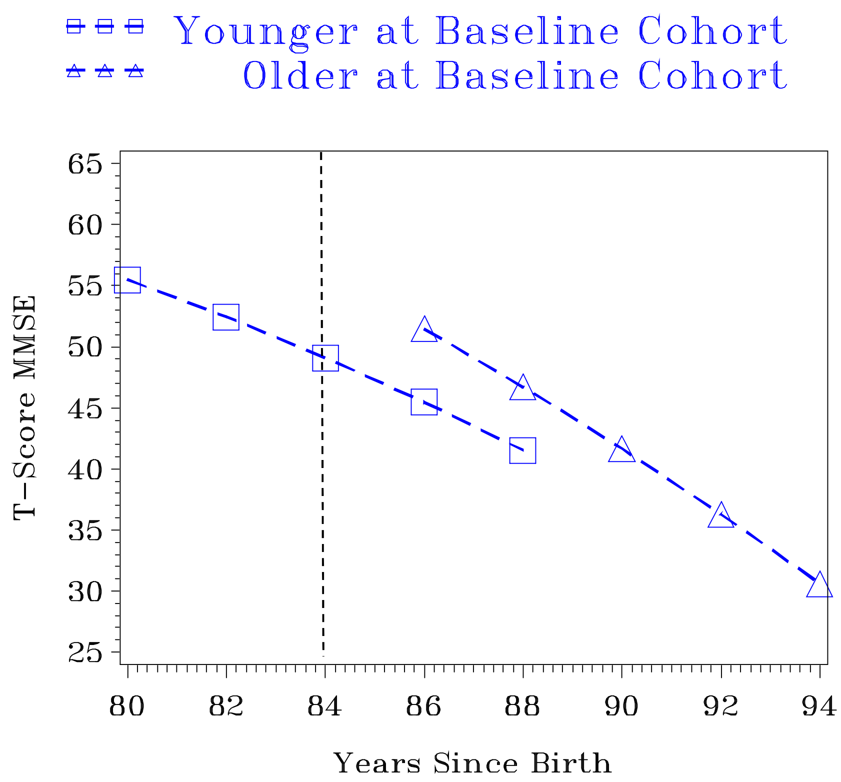
Use **age at time 1** (or birth year) instead of mean age to lessen bias from attrition-related missing data

Significance → Nonconvergence
It matters **WHEN** you were 84

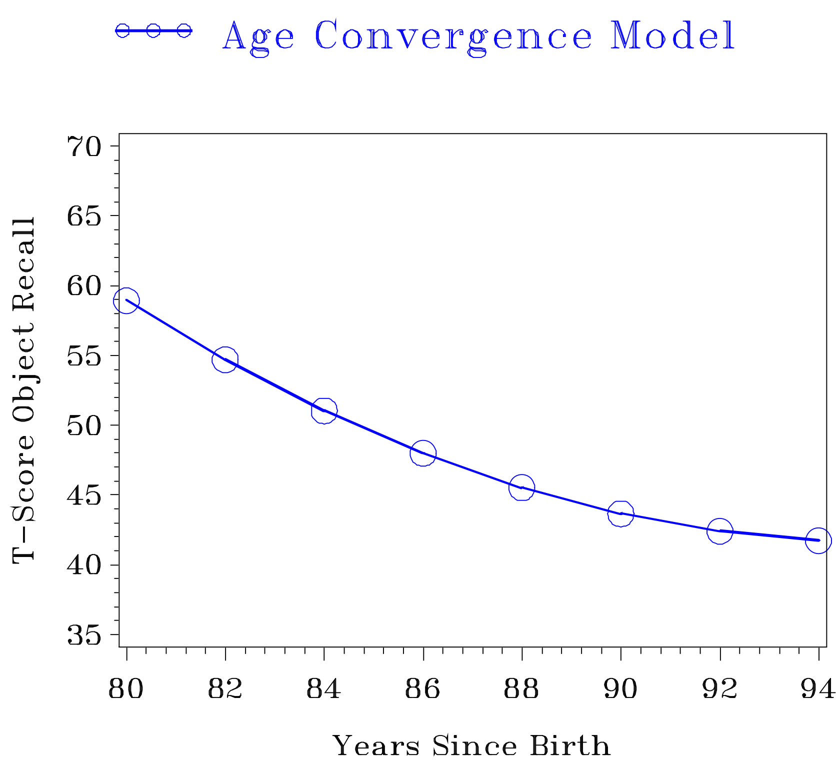
Persons create **contextual effects**

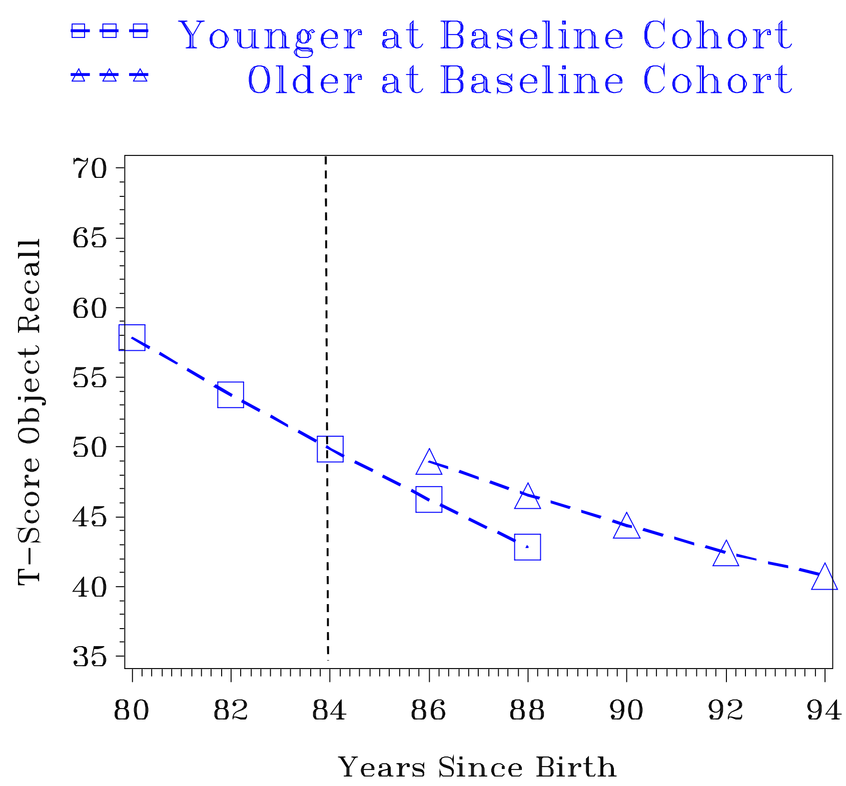
Age-Based Models: MMSE



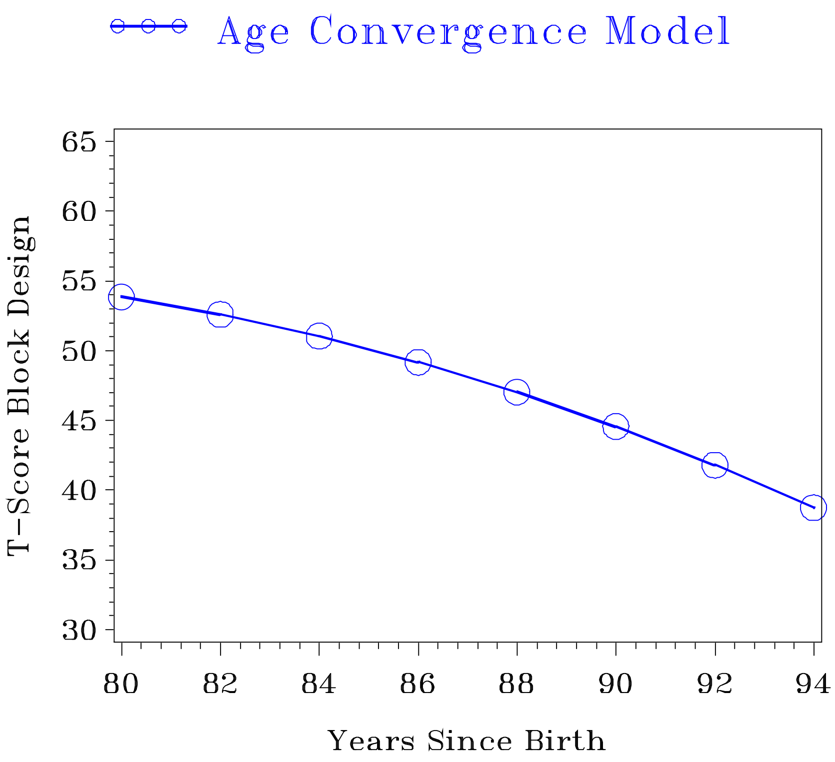


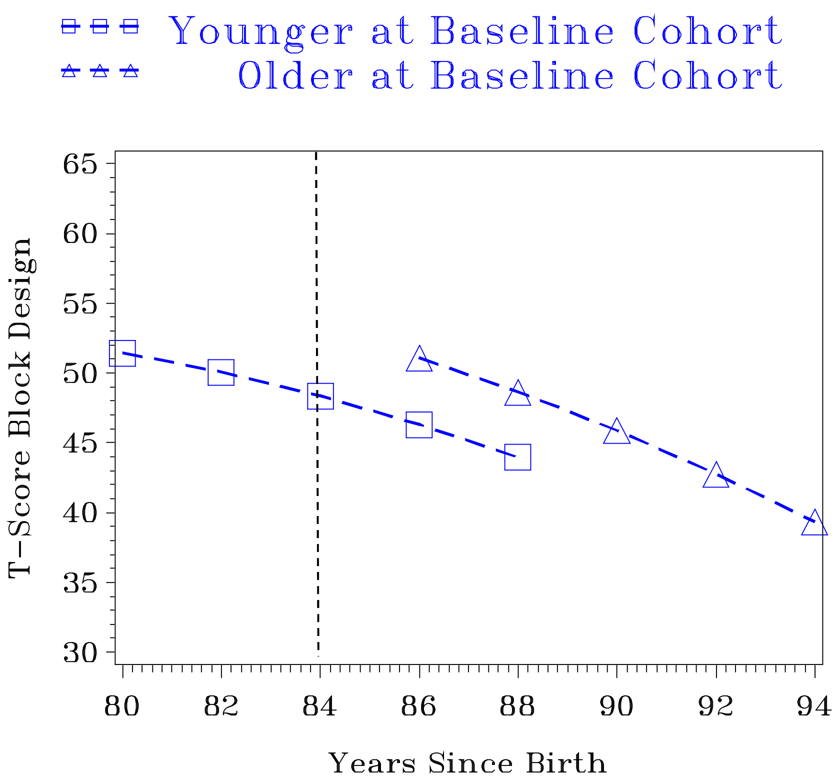
Age-Based Models: Object Recall





Age-Based Models: Spatial Reasoning





So if age is just a time-varying predictor…

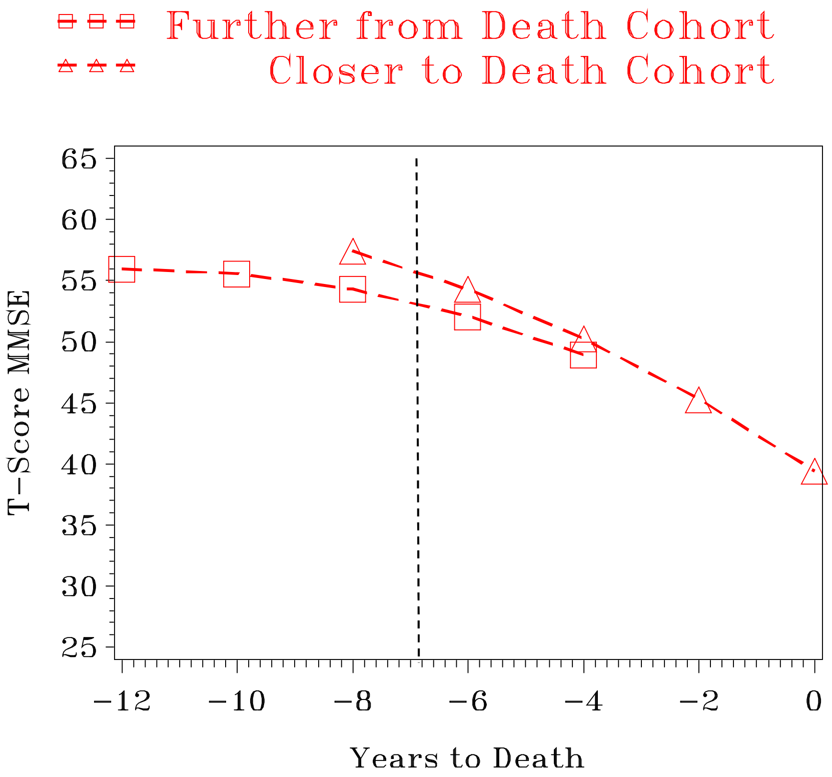
- Because **years to death** and **years to diagnosis** also have BP variation (24%, 70%), the same concerns about **testing convergence** apply to them, too

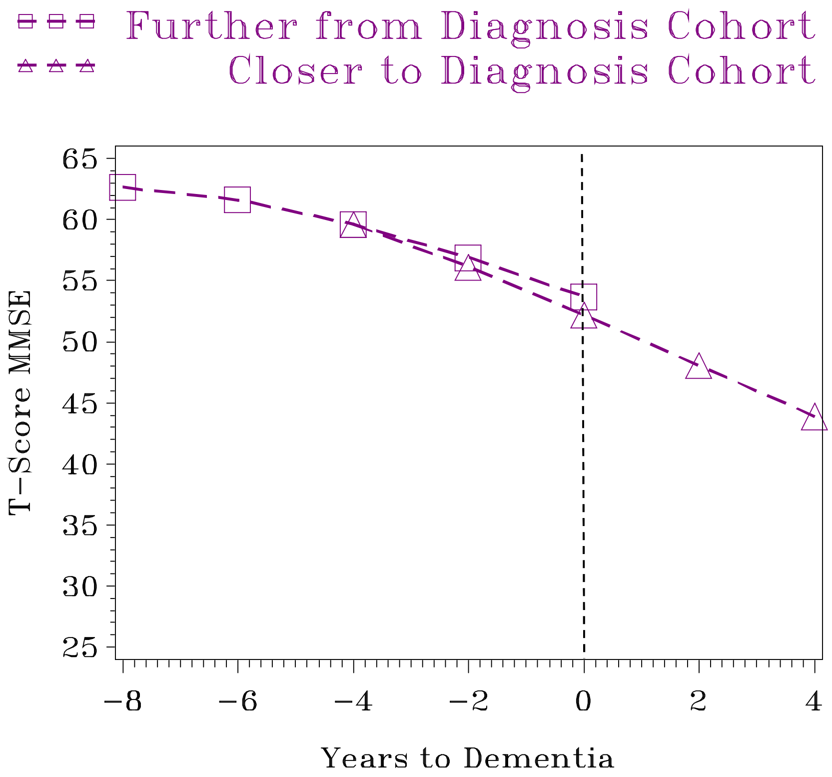
- **Years to death**
  - Level 1: YTdeath_{ti} + 7
  - Level 2: YTdeathT1_{i} + 7
- **Years to diagnosis**
  - Level 1: YTdem_{ti} – 0
  - Level 2: YTdemT1_{i} – 0

- If the level-2 effects in these models are significant, then:
  - **Years to death**: it matters **WHEN** you were 7 years from death
  - **Years to diagnosis**: it matters **WHEN** you were at diagnosis

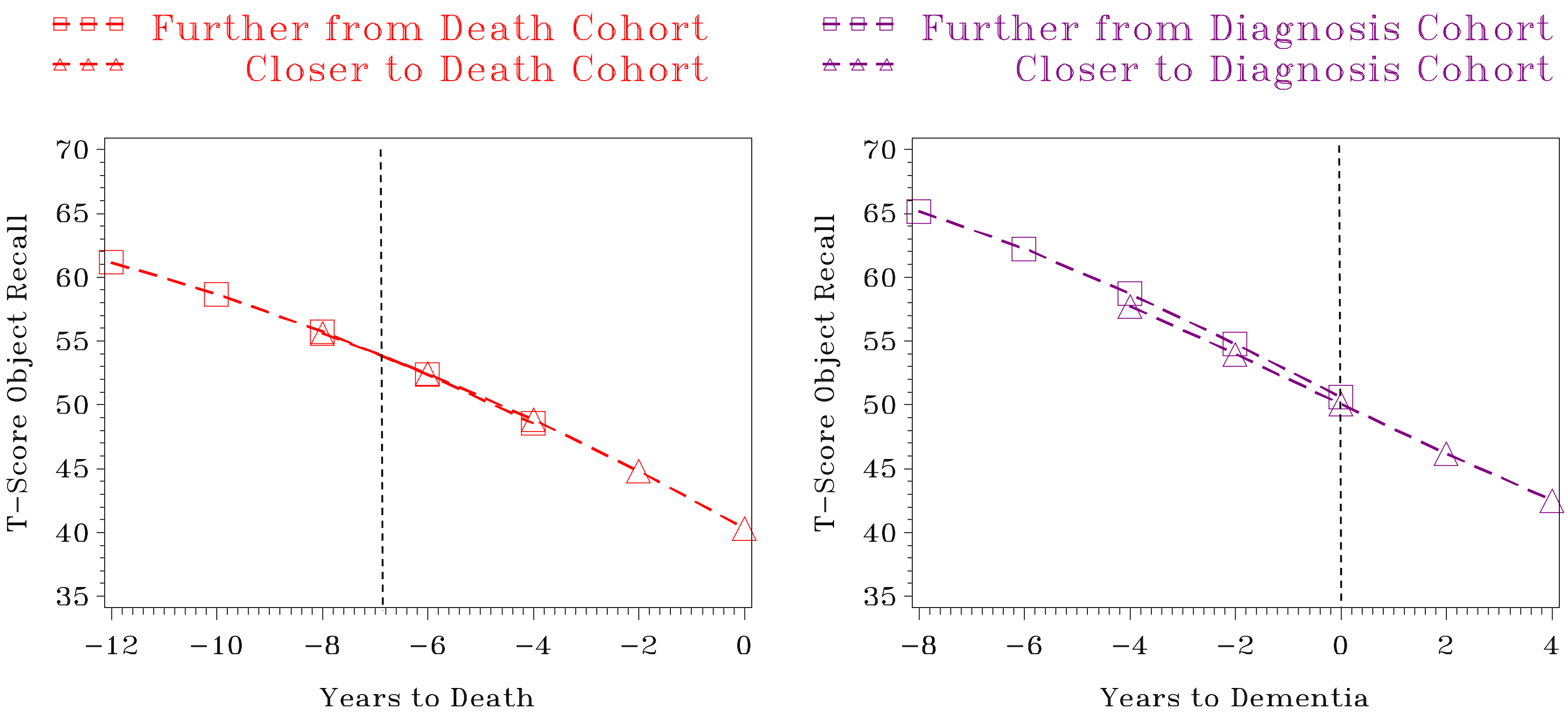
WHEN = cohort difference

Death-Based and Dementia-Based Models: MMSE

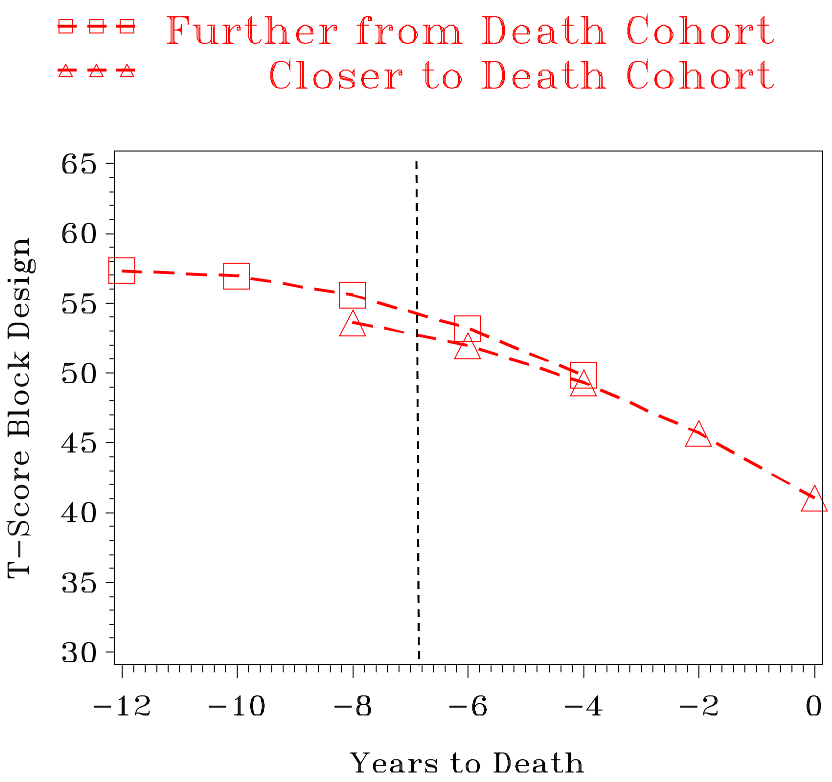


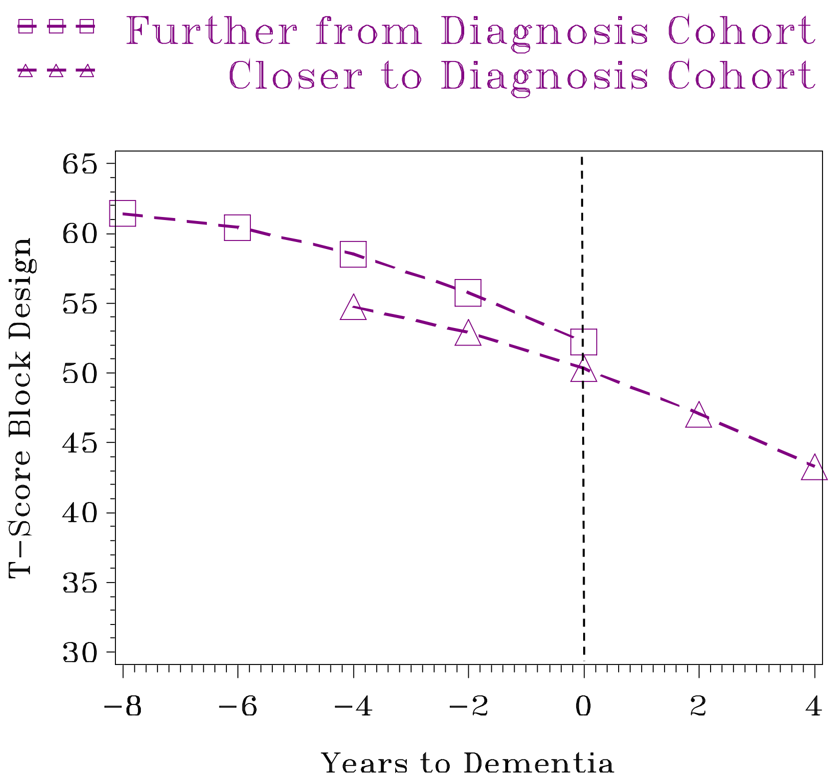


Death-Based and Dementia-Based Models: Object Recall



Death-Based and Dementia-Based Models: Spatial Reasoning

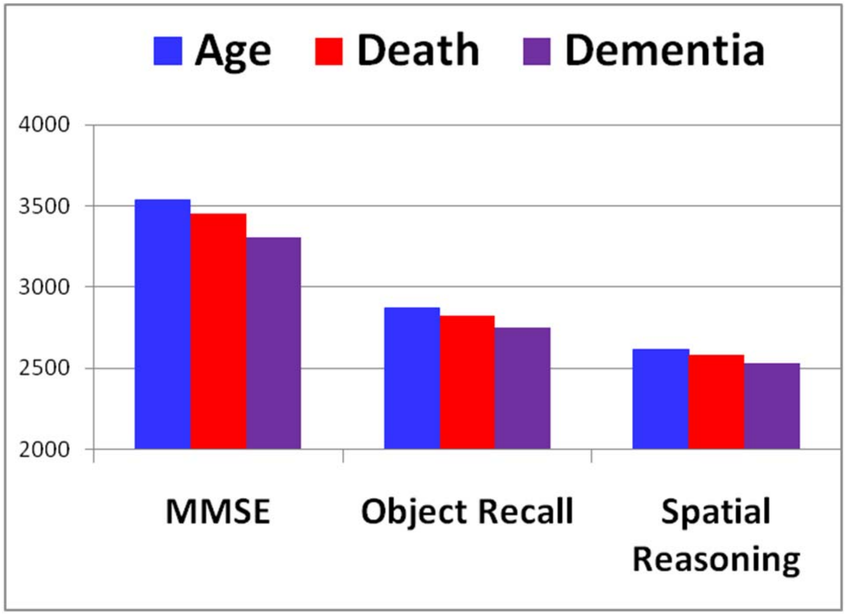




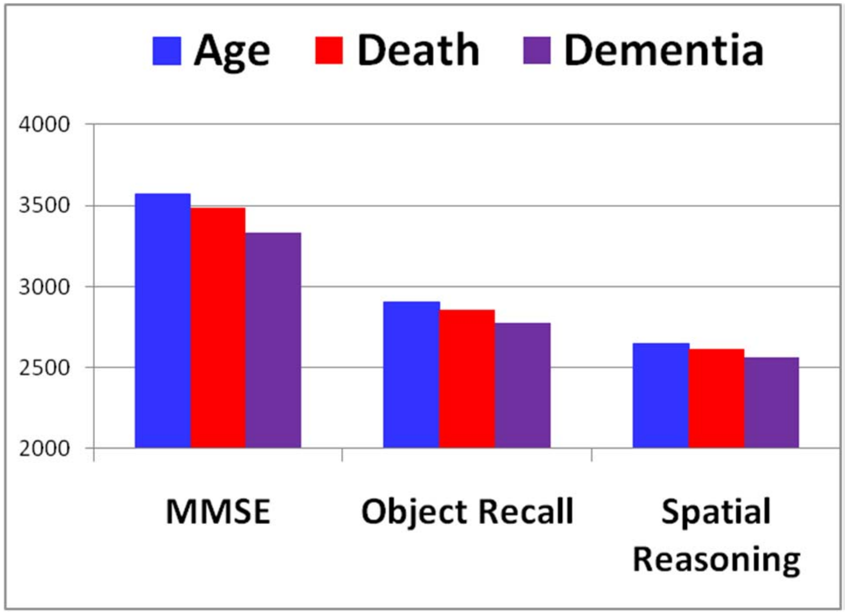
Comparing Models by Fit…

The fit of these alternative metrics of time to the data can be compared using their **information criteria**…

ML AIC



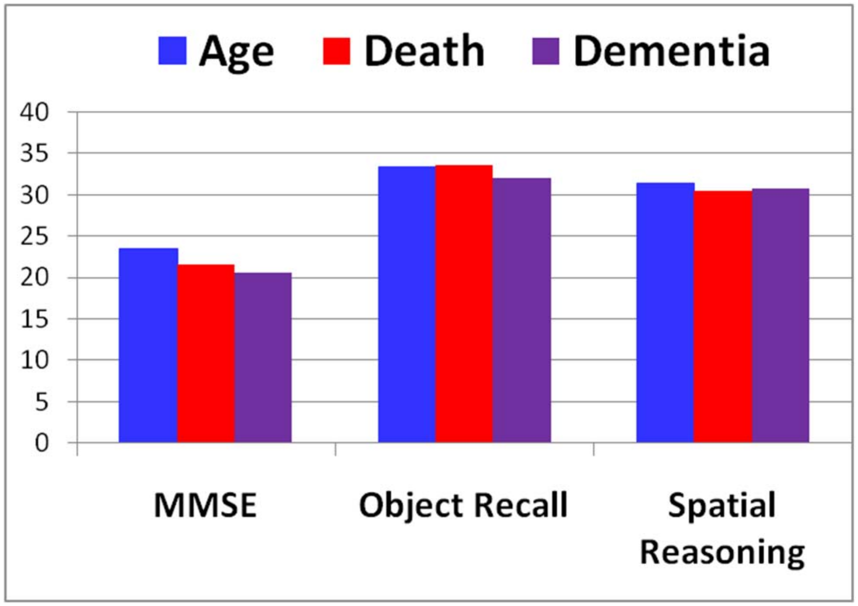
ML BIC



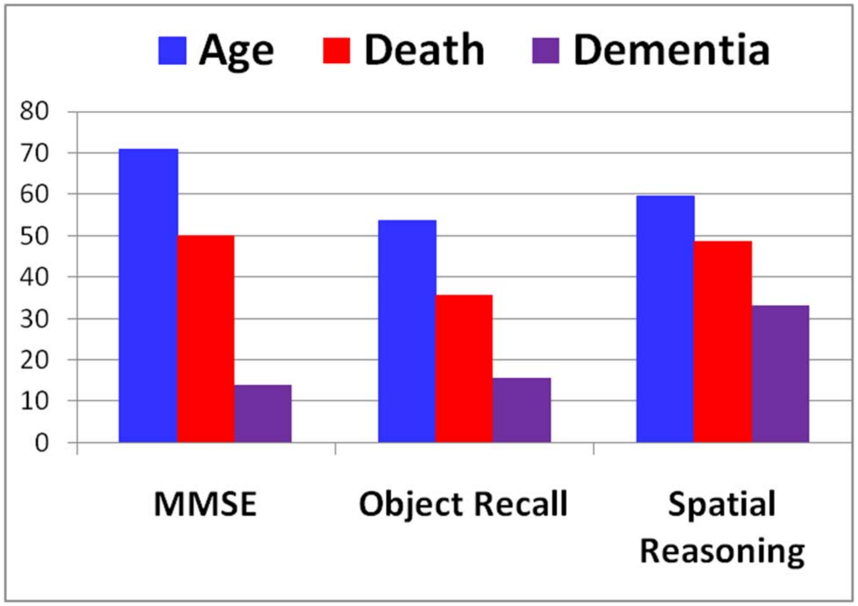
Comparing Models by Variances…

The fit of these alternative metrics of time to the data can also be compared using their **variance** components…

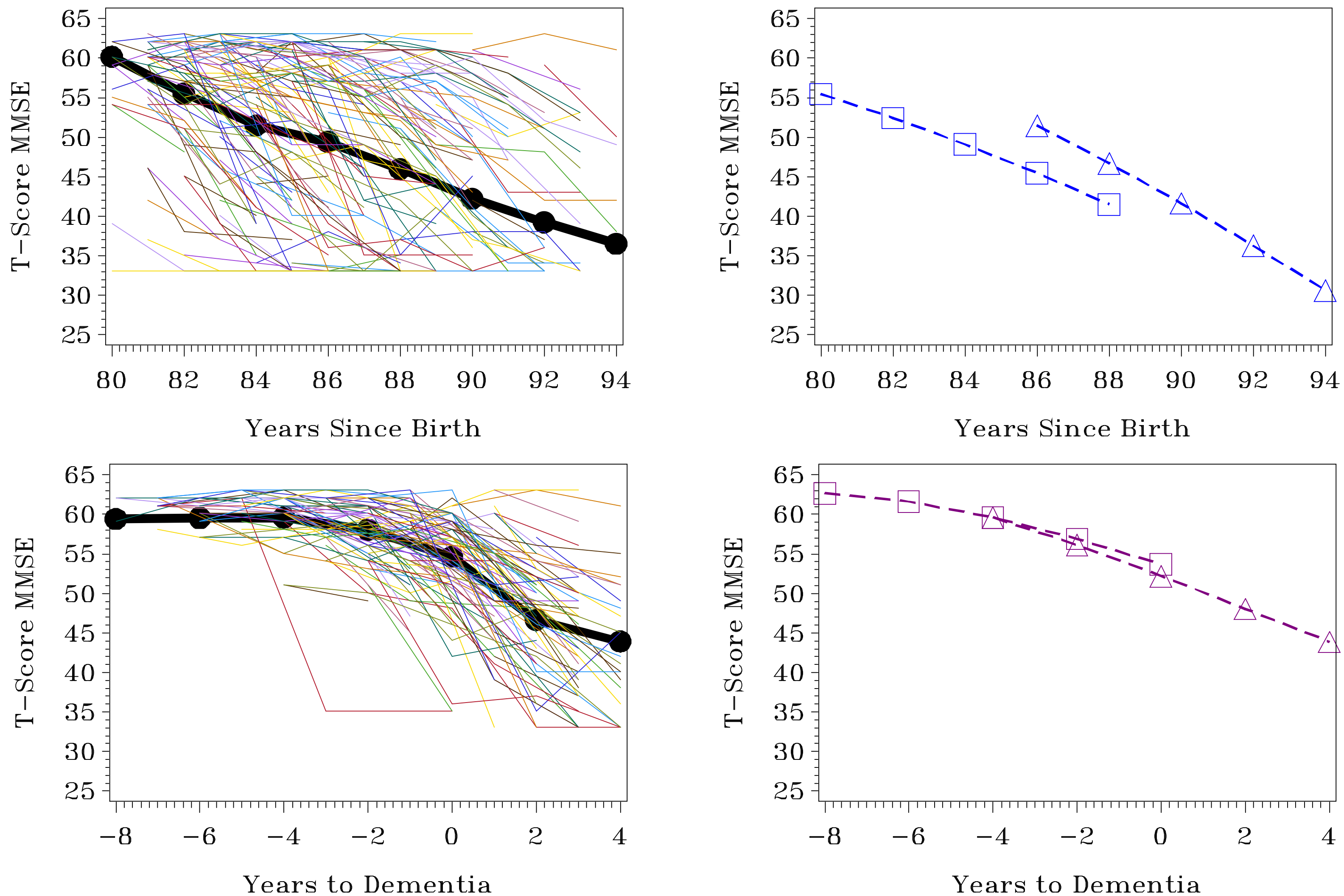
Residual Variance



Intercept Variance



Comparing Models By Data…



Road Map

- Steps in longitudinal analysis
- The missing step #2
- Example: Alternative metrics of "time"
- **What about just time?**
- What else contributes to "time"?

What about just time as "Time"?

- When the accelerated time metrics do not show convergence of their BP and WP time effects, an alternative model specification may be more useful

- **Time-in-study models** separate BP and WP effects
  - Accelerated time (age, death…) model → Grand-mean-centering
  - Time-in-study model → **Person/group-mean-centering**

- Time-in-study models **can be made equivalent** to models with accelerated time metric in their fixed effects, but not in their random effects (as shown shortly)

Just Time as "Time"

Original Age
Age_{ti}
80
82
84
80
82
84
84
86
88
84
86
88

Just Time as "Time"

BP Age	Original Age	WP Age
$AgeT1_i$	Age_{ti}	$Age_{ti} - AgeT1_i$
80	80	0
80	82	2
80	84	4
80	80	0
80	82	2
80	84	4
84	84	0
84	86	2
84	88	4
84	84	0
84	86	2
84	88	4

Just Time as "Time"

BP Age $AgeT1_i$	Original Age Age_{ti}	WP Age $Age_{ti} - AgeT1_i$	Original YTD $YTdeath_{ti}$
80	80	0	-12
80	82	2	-10
80	84	4	-8
80	80	0	-8
80	82	2	-6
80	84	4	-4
84	84	0	-12
84	86	2	-10
84	88	4	-8
84	84	0	-8
84	86	2	-6
84	88	4	-4

Just Time as "Time"

BP Age $AgeT1_i$	Original Age Age_{ti}	WP Age $Age_{ti} - AgeT1_i$	BP Years to Death $YTdeathT1_i$	Original YTD $YTdeath_{ti}$	WP Years to Death $YTdeath_{ti} - YTdeathT1_i$
80	80	0	-12	-12	0
80	82	2	-12	-10	2
80	84	4	-12	-8	4
80	80	0	-8	-8	0
80	82	2	-8	-6	2
80	84	4	-8	-4	4
84	84	0	-12	-12	0
84	86	2	-12	-10	2
84	88	4	-12	-8	4
84	84	0	-8	-8	0
84	86	2	-8	-6	2
84	88	4	-8	-4	4

Just Time as "Time"

Time: Years in Study	BP Age $AgeT1_i$	Original Age Age_{ti}	WP Age $Age_{ti} - AgeT1_i$	BP Years to Death $YTdeathT1_i$	Original YTD $YTdeath_{ti}$	WP Years to Death $YTdeath_{ti} - YTdeathT1_i$
0	80	80	0	-12	-12	0
2	80	82	2	-12	-10	2
4	80	84	4	-12	-8	4
0	80	80	0	-8	-8	0
2	80	82	2	-8	-6	2
4	80	84	4	-8	-4	4
0	84	84	0	-12	-12	0
2	84	86	2	-12	-10	2
4	84	88	4	-12	-8	4
0	84	84	0	-8	-8	0
2	84	86	2	-8	-6	2
4	84	88	4	-8	-4	4

Model Variants Using Age

Level-1 Age-Based (Grand-MC):

$$y_{ti} = \beta_{0i} + \beta_{1i}(Age_{ti} - 84) + e_{ti}$$

Level-1 Time-Based (Person-MC):

$$y_{ti} = \beta_{0i} + \beta_{1i}(Age_{ti} - AgeT1_i) + e_{ti}$$

Same pattern would result in any other accelerated time metric (such as years to death)

Same Level-2 Equations:

$$\beta_{0i} = \gamma_{00} + \gamma_{01}(AgeT1_i - 84) + U_{0i}$$
$$\beta_{1i} = \gamma_{10} + \gamma_{11}(AgeT1_i - 84) + U_{1i}$$

Level-2 AgeT1 effects:

Age-Based: ***Incremental*** effect of cross-sectional age (***contextual*** age cohort effect)

Time-Based: ***Total*** effect of cross-sectional age (***between-person*** age effect)

Effect of Age Cohort on Intercept (Fixed Level-1 Linear Age Slope)

Time-in-Study ≈ Person-MC:

Level 1: $y_{ti} = \beta_{0i} + \beta_{1i}(Age_{ti} - AgeT1_i) + e_{ti}$

Level 2: $\beta_{0i} = \gamma_{00} + \gamma_{01}(AT1_i) + U_{0i}$

$\beta_{1i} = \gamma_{10}$

→ $y_{ti} = \gamma_{00} + \gamma_{01}(AT1_i) + \gamma_{10}(Age_{ti} - AT1_i) + U_{0i} + e_{ti}$ ←**In terms of Time**

→ $y_{ti} = \gamma_{00} + (\gamma_{01} - \gamma_{10})(AT1_i) + \gamma_{10}(Age_{ti}) + U_{0i} + e_{ti}$ ←**In terms of Age**

Age-Based ≈ Grand-MC:

Level 1: $y_{ti} = \beta_{0i} + \beta_{1i}(Age_{ti}) + e_{ti}$

Level 2: $\beta_{0i} = \gamma_{00} + \gamma_{01}(AT1_i) + U_{0i}$

$\beta_{1i} = \gamma_{10}$

→ $y_{ti} = \gamma_{00} + \gamma_{01}(AT1_i) + \gamma_{10}(Age_{ti}) + U_{0i} + e_{ti}$

Term	Time	Age
Intercept	γ_{00}	γ_{00}
WP Effect	γ_{10}	γ_{10}
Contextual	$\gamma_{01} - \gamma_{10}$	γ_{01}
BP Effect	γ_{01}	$\gamma_{01} + \gamma_{10}$

Effect of Age Cohort on Level-1 Age Slope (Fixed Level-1 Linear Age Slope)

On left below: Time-in-Study ≈ Person-MC:

Time as Time: $y_{ti} = \gamma_{00} + \gamma_{10}(Age_{ti} - AT1_i) + \gamma_{11}(Age_{ti} - AT1_i)(AT1_i) + \gamma_{01}(AT1_i) + \gamma_{02}(AT1_i^2) + U_{0i} + e_{ti}$

Time as Age: $y_{ti} = \gamma_{00} + \gamma_{10}(Age_{ti}) + \gamma_{11}(Age_{ti})(AT1_i) + (\gamma_{01} - \gamma_{10})(AT1_i) + (\gamma_{02} - \gamma_{11})(AT1_i^2) + U_{0i} + e_{ti}$

On right below: Age-Based ≈ Grand-MC:

$$y_{ti} = \gamma_{00} + \gamma_{10}(Age_{ti}) + \gamma_{11}(Age_{ti})(AT1_i) + \gamma_{01}(AT1_i) + \gamma_{02}(AT1_i)^2 + U_{0i} + e_{ti}$$

Adding $AgeT1^2$ creates equivalence

Intercept: $\gamma_{00} = \gamma_{00}$ | **BP Effect:** $\gamma_{01} = \gamma_{01} + \gamma_{10}$ | **Cohort:** $\gamma_{01} = \gamma_{01} - \gamma_{10}$

WP Effect: $\gamma_{10} = \gamma_{10}$ | **BP² Effect:** $\gamma_{02} = \gamma_{02} + \gamma_{11}$ | **Cohort²:** $\gamma_{02} = \gamma_{02} - \gamma_{11}$

BP*WP or Cohort*WP is the same: γ_{11}

Add Quadratic Level-1 Age Slope (Fixed Level-1 Age Slopes)

On left below: Time-in-Study ≈ Person-MC:

Time as Time: $y_{ti}=\gamma_{00}+\gamma_{10}(Age_{ti}-AT1_i)+\gamma_{20}(Age_{ti}-AT1_i)^2$
$+\gamma_{11}(Age_{ti}-AT1_i)(AT1_i)+\gamma_{01}(AT1_i)+\gamma_{02}(AT1_i^2)+U_{0i}+e_{ti}$

Time as Age: $y_{ti}=\gamma_{00}+\gamma_{10}(Age_{ti})+\gamma_{20}(Age_{ti}^2)+(\gamma_{11}-2\gamma_{20})(Age_{ti})(AT1_i)$
$+(\gamma_{01}-\gamma_{10})(AT1_i)+(\gamma_{02}+\gamma_{20}-\gamma_{11})(AT1_i^2)+U_{0i}+e_{ti}$

On right below: Age-Based ≈ Grand-MC:

$y_{ti}=\gamma_{00}+\gamma_{10}(Age_{ti})+\gamma_{20}(Age_{ti})^2+\gamma_{11}(Age_{ti})(AT1_i)$
$+\gamma_{01}(AT1_i)+\gamma_{02}(AT1_i)^2+U_{0i}+e_{ti}$

Intercept: $\gamma_{00}=\gamma_{00}$ **BP Effect:** $\gamma_{01}=\gamma_{01}+\gamma_{10}$ **Cohort:** $\gamma_{01}=\gamma_{01}-\gamma_{10}$

WP Effect: $\gamma_{10}=\gamma_{10}$ **BP² Effect:** $\gamma_{02}=\gamma_{02}+\gamma_{11}+\gamma_{20}$ **Cohort²:** $\gamma_{02}=\gamma_{02}-\gamma_{11}+\gamma_{20}$

WP² Effect: $\gamma_{20}=\gamma_{20}$ **BP*WP:** $\gamma_{11}=\gamma_{11}+2\gamma_{20}$ **Cohort*WP:** $\gamma_{11}=\gamma_{11}-2\gamma_{20}$

Time-in-Study Models so far…

- Specify WP change using only longitudinal information
- Are equivalent within persons across accelerated time metrics
- Because unique information from the alternative time metrics is really only available BP, it only shows up in the level-2 model
- Can (usually) be made equivalent in their fixed effects to models based in alternative accelerated time metrics
- **So why make a distinction? Different random effects…**

Random Slopes Across Models

Time-in-Study ≈ Person-MC:

as Time: $y_{ti} = \gamma_{00} + \gamma_{10}(Age_{ti} - AT1_i) + \gamma_{01}(AT1_i)$

$+ U_{0i} + U_{1i}(Age_{ti} - AT1_i) + e_{ti}$

as Age: $y_{ti} = \gamma_{00} + \gamma_{10}(Age_{ti}) + (\gamma_{01} - \gamma_{10})(AT1_i)$

$+ U_{0i} + \boxed{U_{1i}(Age_{ti}) - U_{1i}(AT1_i)} + e_{ti}$

Age-Based ≈ Grand-MC:

$y_{ti} = \gamma_{00} + \gamma_{10}(Age_{ti}) + \gamma_{01}(AT1_i)$

$+ U_{0i} + \boxed{U_{1i}(Age_{ti})} + e_{ti}$

So which do we choose?

Variance due to $AT1_i$ is still part of the random slope in the age-based model. So the time-based and age-based models cannot be made equivalent in terms of random effects variances.

Random Slopes Across Models

- **Random intercepts** mean different things under each model:
  - **Time: Person-MC** → Individual differences at **time=0** (that everyone has)
  - **Age: Grand-MC** → Individual differences at **age=0** (that not everyone has)

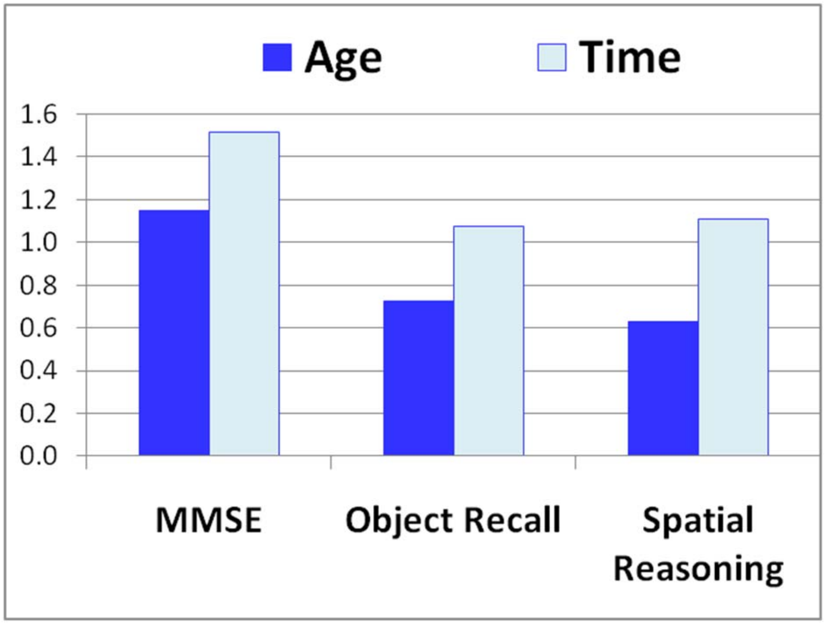
- **Differential shrinkage of the random intercepts** results from differential reliability of the intercept data across models:
  - **Person-MC** → Won't affect shrinkage of slopes unless highly correlated
  - **Grand-MC** → Will affect shrinkage of slopes due to forced extrapolation

- As a result, the **random slope variance may be smaller** under **grand-MC (age, death…)** than under **person-MC (time)**
  - Problem worsens with greater BP variation in time (more extrapolation)
  - Anecdotal example of downward bias using clustered data was presented in Raudenbush & Bryk (2002; chapter 6), but what about in these data?

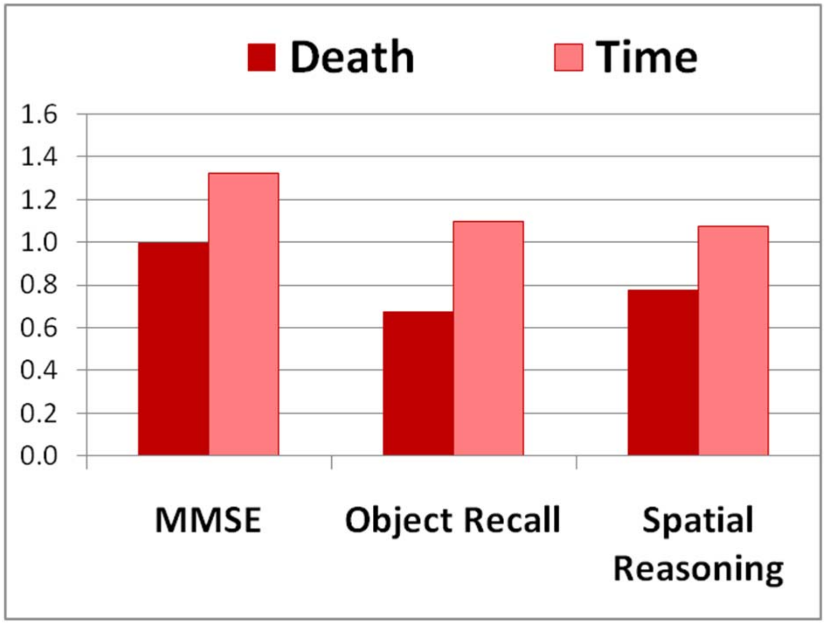
Slope Variance in Example Models

- Slope variance estimate was indeed **33-77% larger** in the time-based model versions across outcomes…

Years-Since-Birth (47% BP)

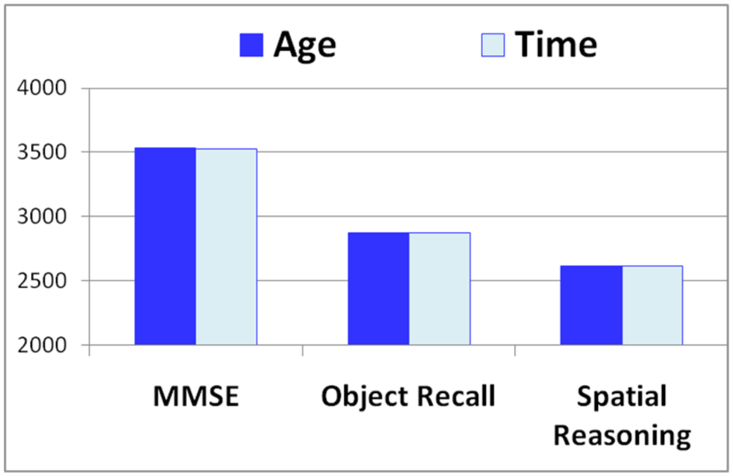


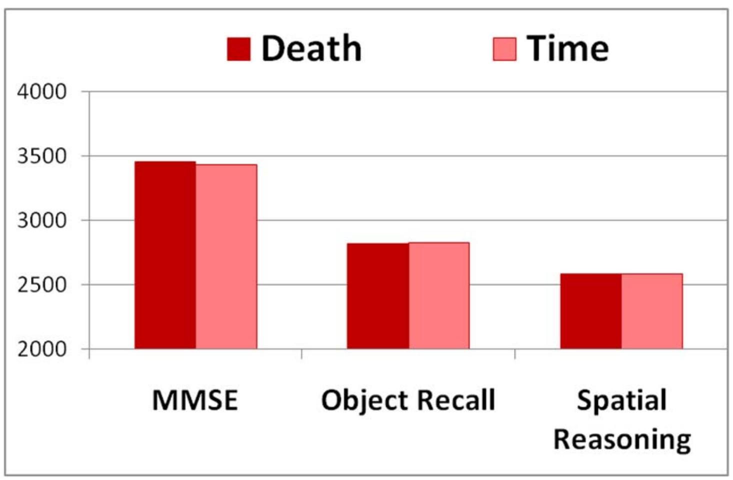
Years-to-Death (24% BP)



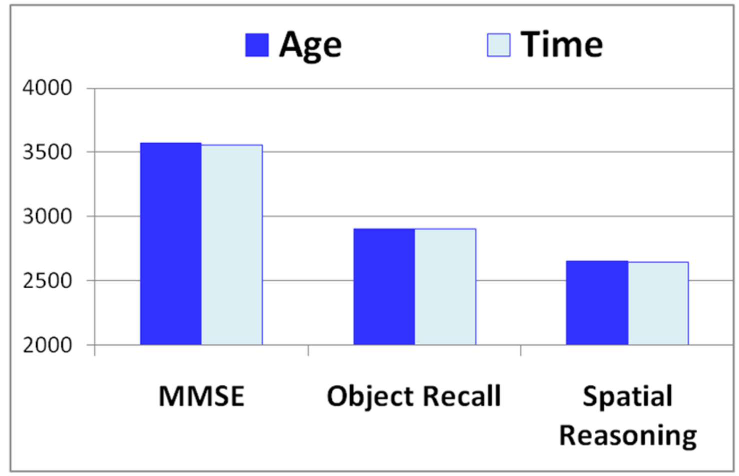
… Although model fit was the same

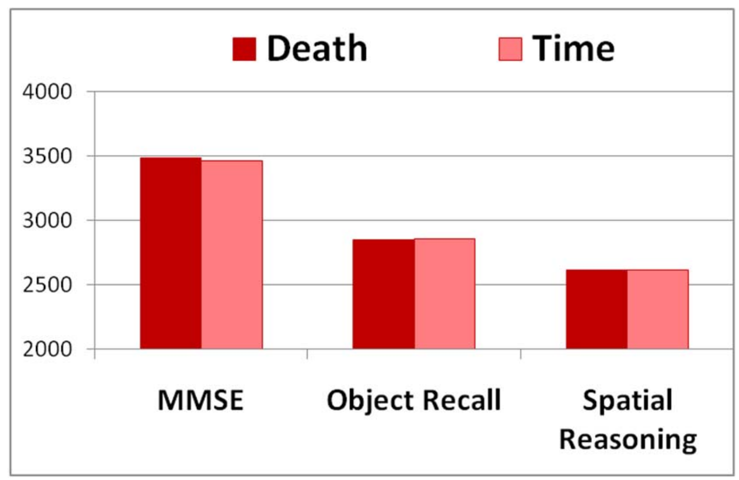
ML AIC



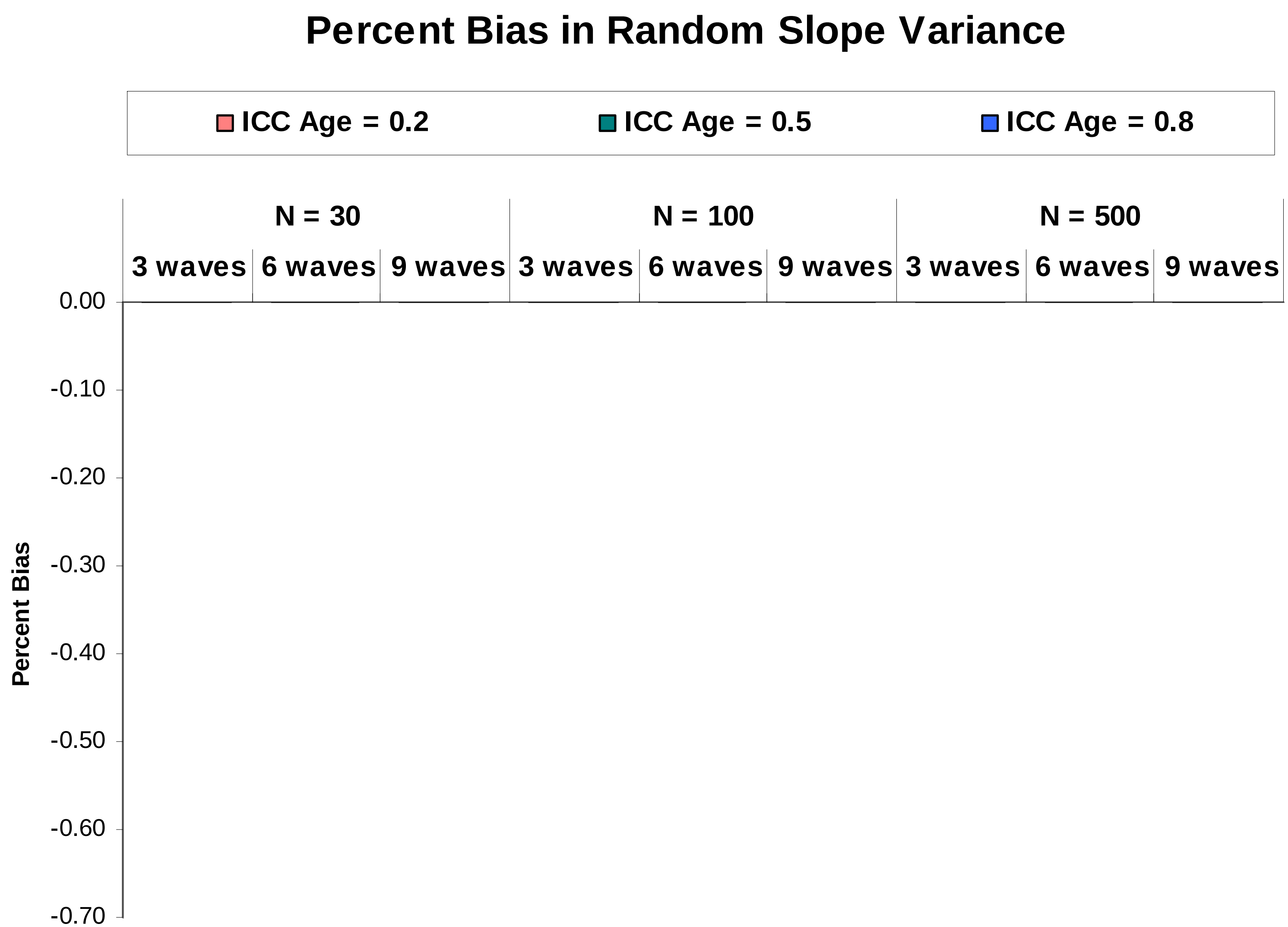


ML BIC

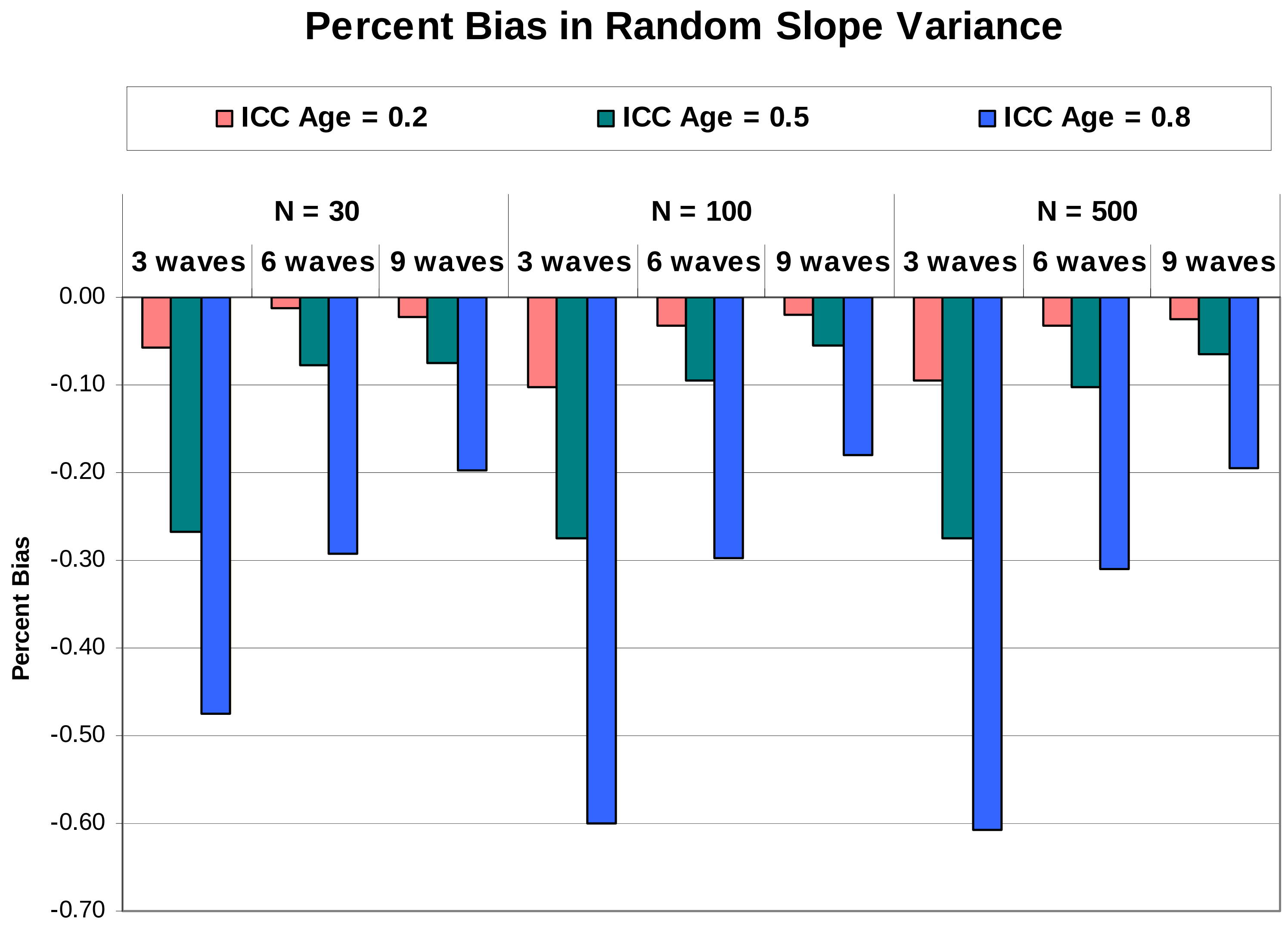




Simulation Study Results
(Generated by Time, Analyzed by Age)



Simulation Study Results
(Generated by Time, Analyzed by Age)



And so the winner is… Time?

- Although seemingly the most non-informative choice, simply tracking **change as a function of study duration**:
  - Represents **WP changes** as directly and parsimoniously as possible
  - Seems to recover **random slope variance** better in accelerated designs
  - Permits inclusion of persons who have not experienced events in an alternative time metric (e.g., death, dementia diagnosis)

- Time-in-study models make no assumptions about processes causing change, so these become **testable hypotheses**
  - Do persons who are older start lower and decline faster?
    - *Age main effect, Age*Time interaction*
  - After considering mortality, do older persons *still* decline faster?
    - *Competing YTdeath*Time and Age*Time interactions*

Road Map

- Steps in longitudinal analysis
- The missing step #2
- Example: Alternative metrics of "time"
- What about just time?
- **What else contributes to "time"?**

What about retest effects?

- Are estimates of age-related change too small without controlling for **practice effects** due to repeated testing?

- Can **time-in-study** index **retest** in age-based models?

$$\mathbf{y_{ti} = \gamma_{00} + \gamma_{10}(Age_{ti}) + \gamma_{20}(Age_{ti})^2 \ldots}$$
$$\mathbf{+\ e_{ti} + U_{0i} + U_{1i}(Age_{ti}) + \ldots}$$
$$\mathbf{+\ \gamma_{30}(Retest_{ti})}$$
$$\mathbf{+\ \gamma_{40}(Retest_{ti})(Age_{ti}) \ldots}$$

Individual change due to age

Retest = Time = Difference due to which occasion of measurement

- But not including age cohort assumes **age convergence**… What if age cohort (AT1) and retest effects are BOTH included?
  - Simulation results: missing cohort effects will masquerade as retest effects in the opposite direction—they are **confounded by design**

Conclusions

- When time has both BP and WP variation, one should always **carefully consider what "time" could and should be**
  - Otherwise, aggregate trends may not actually describe any individuals
  - Individual differences can be created artificially through the mis-alignment of different persons onto a single "time" trajectory
- **Multiple processes** may be at work simultaneously, but they have to be **observed independently** to be distinguishable
  - Age vs. Mortality: can be distinguished if not everyone dies at same age
  - But if **aging and retest occur simultaneously within-persons**, retest effects cannot be distinguished from effects of aging and age cohort
  - **Age/Cohort/Time in design → Age/Cohort/Retest in models**
- Considering the effects of time is an important pre-cursor to making informed use of advances in longitudinal models…

Thank you for your time...

- **Questions or comments? Email me: Lesa@unl.edu**
- **Slides available at: http://psych.unl.edu/hoffman/Sheets/Talks.htm**
- Works cited:

  - Hoffman, L., Hofer, S. M., & Sliwinski, M. J. (2011). On the confounds among retest gains and age-cohort differences in the estimation of within-person change in longitudinal studies: A simulation study. *Psychology and Aging, 26*(4), 778-791.
  - Hoffman, L. (2012). *Considering alternative metrics of time: Does anybody really know what "time" is*? In J. Harring & G. Hancock (Eds.), *Advances in Longitudinal Methods in the Social and Behavioral Sciences* (pp. 255-287). Charlotte, NC: Information Age Publishing.
  - Hoffman, L., & Templin, J. L. (April, 2008). *The impact of alternative specifications of time on examining individual differences in change*. Poster presented at the Cognitive Aging Conference, Atlanta, GA.

Time in Within-Person Fluctuation Models

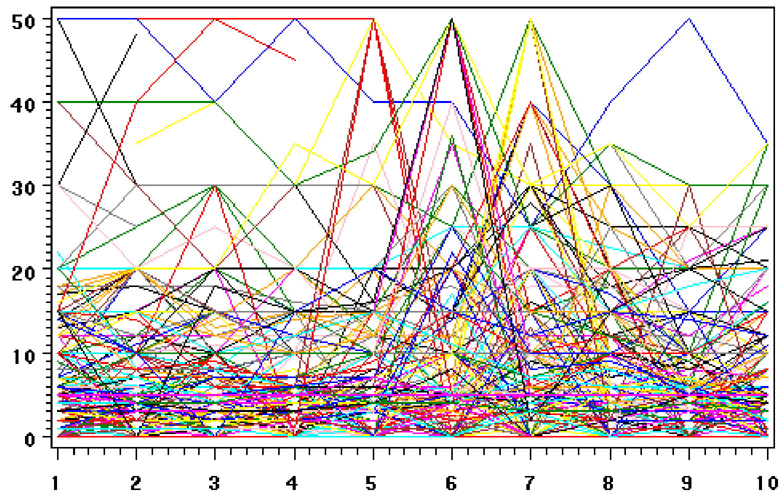
- Even in longitudinal studies focused on **within-person fluctuation rather than change**, time may still be relevant

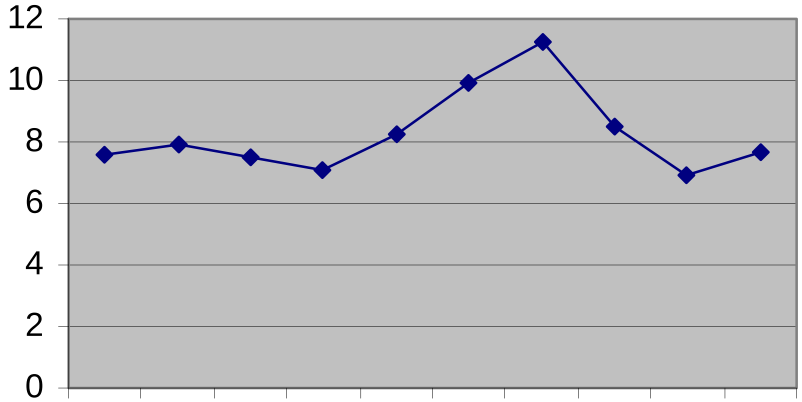
- For instance, in daily diary studies:
  - Day of the Week (time metric could be **day of week**)
  - Fatigue/Reactivity (time metric could be **day of study**)

- In these cases you'd be "controlling for change" instead of "modeling change" (same models, different emphasis)
  - Some examples…

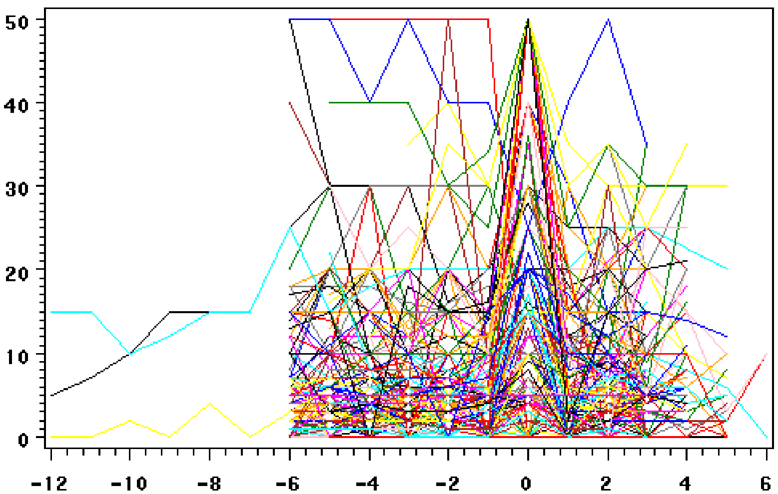
Plans to Drink Alcohol: Time-in-Study vs. Time-to-Event

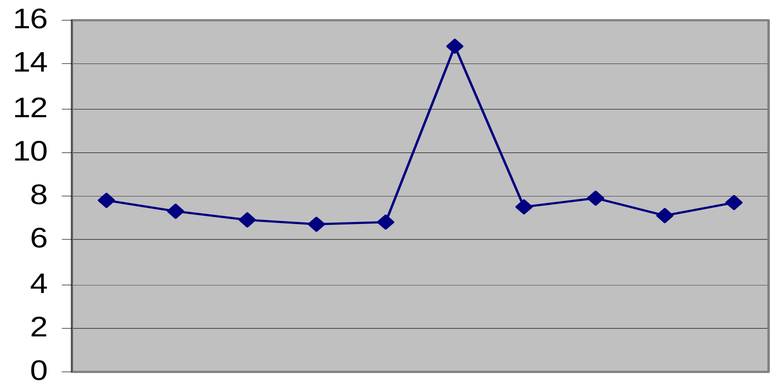
#Drinks by Interview Week Number





#Drinks by Time to Spring Break





Change in Negative Affect over "Time"

Stawski & Sliwinski, GSA 2005

Aging
.24/burst (6 mos.)
p < .0001

Reactivity
-.07/session
p < .01

Measurement Burst Design