

Integrative Analysis of Longitudinal Studies on Aging

# Metrics of time in longitudinal models

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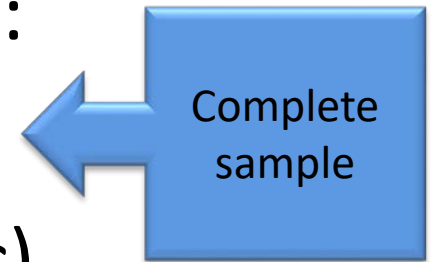
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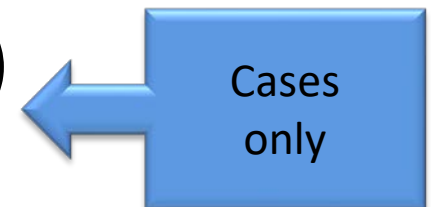
# Models of change

- Random effects models are often used to estimate trajectories
- They require the selection of a metric of time
- Time may be clocked in different ways:
  - age (time since birth)
  - time in study (time past since 1<sup>st</sup>.occ)



But also, for some specific objectives:

- time to / from event (time to death, dementia diagnosis, time past since stroke, etc.)



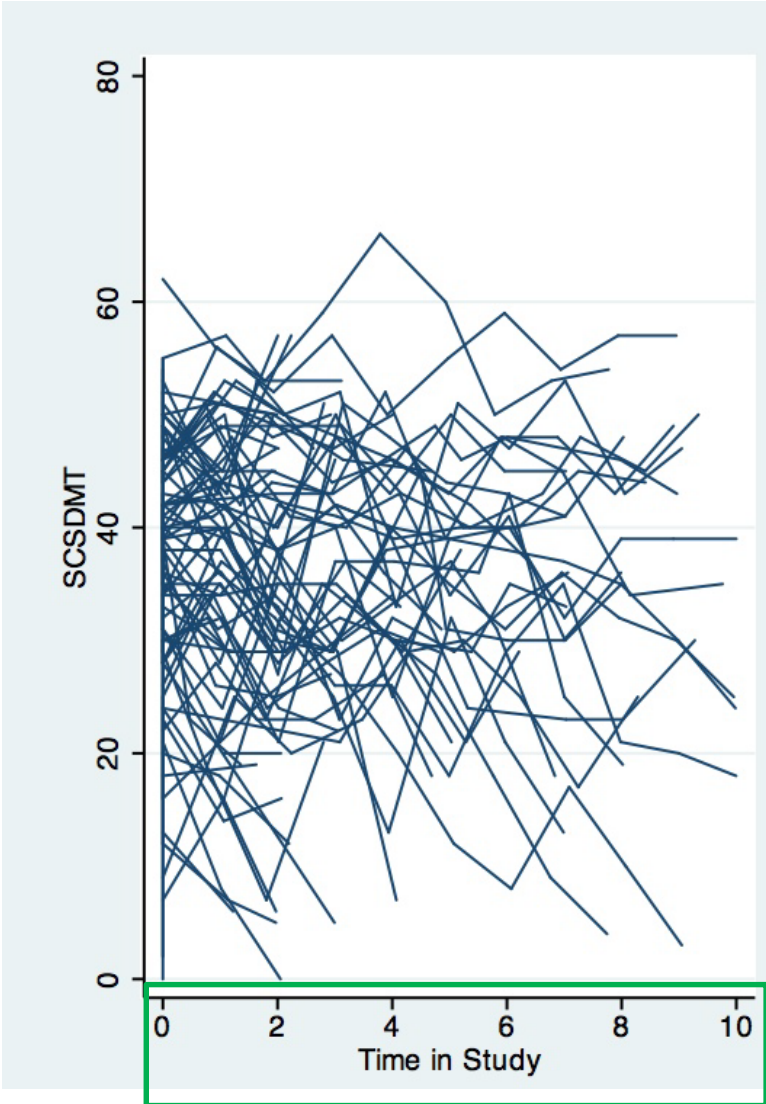
# Some questions when modelling change:

- *Should we expect consistent results from time in study and age-based models?*
- *What factors do we need to think about when choosing a time metric?*
- *Should we model time as time in study or as chronological age?*

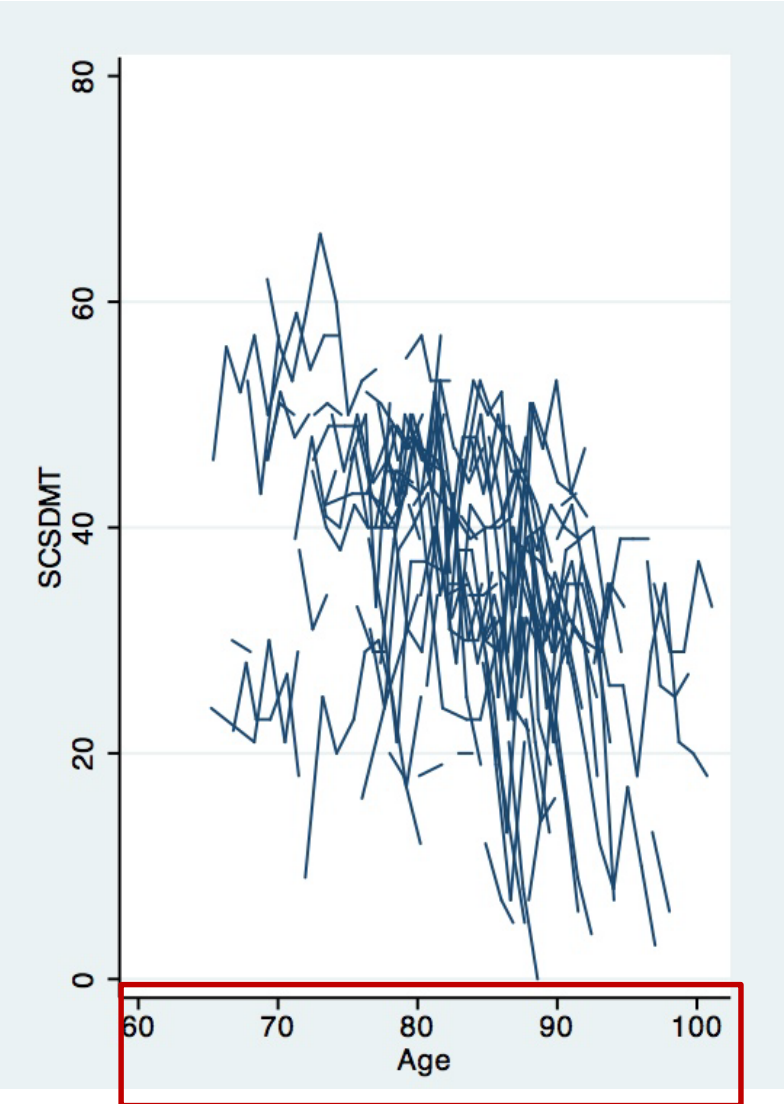
# Example

- *Data:* Memory and Aging Project (longitudinal study begun 1997 that aims to identify factors associated with maintenance of cognitive health despite AD & other pathologies) Bennett et al. 2012
- Oral version of Symbol Digit Modalities test (SDMT):  
Participants shown a series of symbols, each paired with a number from 1 to 9 and then asked to call out the numbers that match the symbols shown to them one at a time (90s to translate as many symbols as they can)

# SDMT scores



10-year span



35<sup>+</sup>-year span

# Three factors to consider when thinking of a time metric:

1. Separation of *age differences at study entry* (cross sectional (XS) or between person) from *aging* (longitudinal (LG) or within person) effects
2. Placement of intercept (time origin) & impact of placement on association with potential risk factors
3. Optimal description of trajectory of change

# 1. Separating XS from LG age effects

“Separation of *age differences at study entry* (cross sectional (XS) or between person) from *aging* (longitudinal (LG) or within person) effects”

- Time in study models: common practice to adjust for baseline age to separate XS from longitudinal effects
- Age based models: not as common to adjust for baseline age (“age is already in the model”) BUT age based models should also be adjusted for baseline age
- Why?

# 1. Separating XS from LG age effects

*Failure to do so:*

- is a form of ecological fallacy (Robinson, 1950): group level relations are mistakenly regarded to be valid at the individual level.
- implicitly assumes convergence: that cross sectional age differences and longitudinal age changes converge into a common trajectory (Sliwinski, Hoffman, Hofer, 2010).
- Produces estimates that are a compound of between & within age effects (Sliwinski, Hoffman, Hofer, 2010).

*Plus:* insight into selection bias / healthy participant effect



## 2. Placement of intercept

*“Placement of intercept (time origin) & impact of placement on association with potential risk factors”*

- Time in study models have a natural “origin”: the 1<sup>st</sup> time individuals are exposed to a test.
- Age-based models require a more arbitrary decision about where to set intercept.
  - achieved using some form of centering (taking away a certain quantity from observed ages).
  - if age not centered, estimate of “level” would represent expected score at birth (in unconditional models (!))

## 2. Placement of intercept

- When arbitrary decisions on centering are made, direct comparison of results across studies is not straightforward.
- In completely balanced designs, varying the intercept may help gain better understanding of associations between risk factors & outcome.
- Does not extend directly to studies with missing data.
- Choice of centering changes associations with risk factors

## 2. Placement of intercept

-choice of centering changes association with risk factors (B. age centered at 79)

	Time conditional	Age conditional centred at 55	Age conditional centred at 75	Age conditional centred at 85
<b>Fixed effects</b>				
Intercept	36.17 (0.28)	66.97 (1.31)	44.96 (0.44)	32.75 (0.32)
Baseline age on intercept	-0.50 (0.04)	1.41 (0.11)	0.56 (0.04)	-0.72 (0.04)
<i>Education on intercept</i>	0.99 (0.09)	1.78 (0.25)	1.13 (0.10)	0.93 (0.09)
<b>Slope</b>				
Baseline age on slope	-1.29 (0.05)	-1.14 (0.05)	-1.14 (0.04)	0.03 (0.003)
Education on slope	-0.08 (0.006)	-0.04 (0.00)	-0.04 (0.004)	0.002 (0.00)
Education on slope	-0.01 (0.01) <sup>NS</sup>	-0.03 (0.01)	-0.03 (0.01)	0.00 (0.001) <sup>NS</sup>

# Age vs. time in study models: interpretation

	Time in study model	Age based model centered at 55
Intercept	Performance <u>at study entry</u> for a person aged 79 years at study entry	Expected performance <u>at age 55 yrs.</u> old for a person aged 79 at study entry
Slope (rate of change over entire period)	Annual <u>rate of change from study entry</u> for an individual aged 79 at study entry	Expected annual <u>rate of change from age 55</u> for a person aged 79 at study entry
Baseline age on intercept	Effect of an extra year of age at study entry on performance at study entry	Effect of an extra year of age at study entry on expected performance at age 55 (for an individual aged 79 at study entry)
Baseline age on slope	Effect of an extra year of age at study entry on rate of change	Effect of an extra year of age at study entry on rate of change from age 55 for an individual aged 79 at study entry.

# 3. Shape

*“Optimal description of trajectory of change”*

- Alignment of scores by Time in study & age may result in different conclusions regarding “shape” of trajectory
- Time in study:
  - data are not widely spread along x-axis,
  - time represents actual window of observation
- Chronological age:
  - extrapolation of time beyond period of observation
  - shape may be estimated purely on between persons data

# 3. Shape

Example:

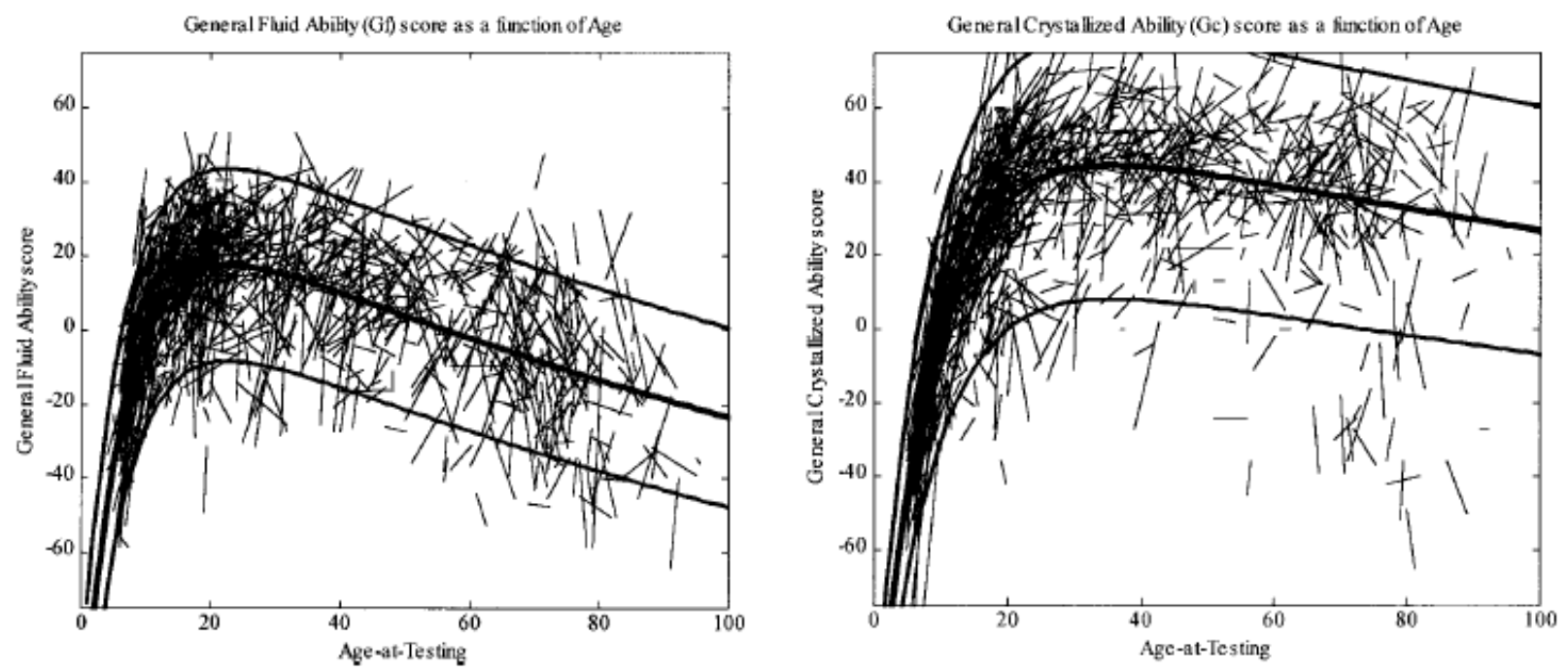


Figure 9. A comparison of multilevel longitudinal age curves for Gf and Gc abilities (Rasch W units).

Dev Psych, 2002, 38(1): 115-142

# In conclusion I

- Regardless of time metric, inclusion of XS information is crucial for correct inferences
- Age-based models may be subject to a higher degree of arbitrariness due to wide choice of centering options for intercept
- As a consequence, associations with risk factors may appear to be inconsistent
- Shape may reflect XS rather than LG within person information in age-based models

# In conclusion II

- When writing papers, it is essential to report decisions made regarding time metric. If not reported, interpretation of results not easy
- If age was the choice, then clear statement regarding where intercept was placed is important to place results in context
- Also, this is important to critically evaluate literature