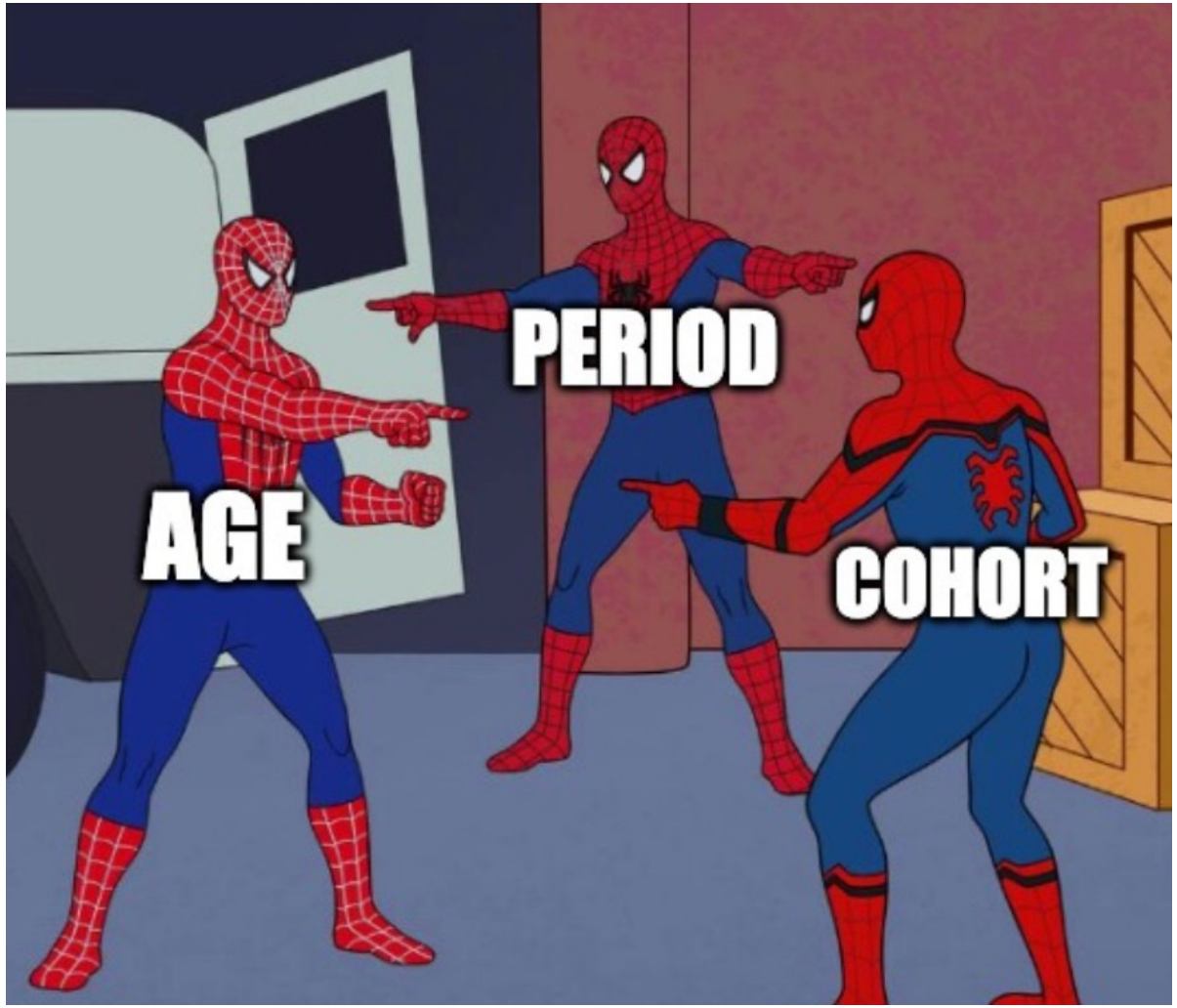


Meme credit: Turgut Keskintürk on Bluesky

Improving inference about personality development with

A new approach to the age-period-cohort problem

Julia M. Rohrer
Leipzig University
juliarohrer.com
www.the100.ci

Full article:
Thinking Clearly About Age, Period, and Cohort Effects

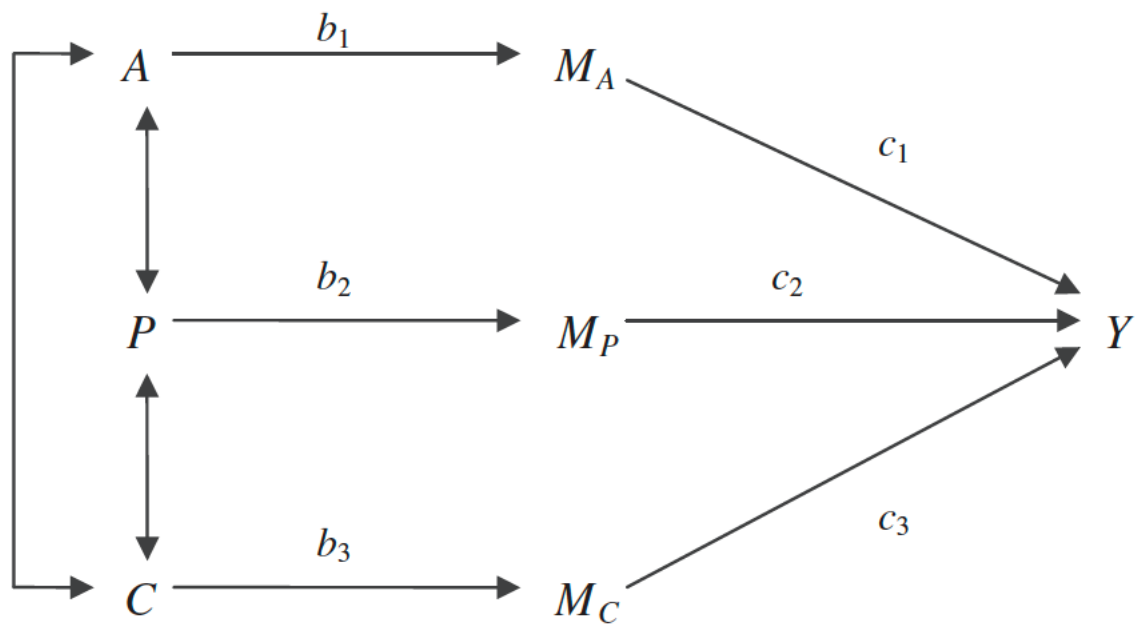
What's an age/period/cohort effect?

- A (causal) effect: contrast between two potential outcomes
  - the effect of time spent preparing this talk on its quality
    - Quality of talk$^{\text{Invested a whole day}}$ – Quality of talk$^{\text{Made the slides on the train}}$, all else being equal
- But how does that work for age/period/cohort?
  - Life satisfaction$^{\text{At age 55}}$ – Life satisfaction$^{\text{At age 35}}$, *all else being equal?*
  - Life satisfaction$^{\text{Year 2025}}$ – Life satisfaction$^{\text{Year 2005}}$, *all else being equal?*
  - Life satisfaction$^{\text{1990 cohort}}$ – Life satisfaction$^{\text{1970 cohort}}$, *all else being equal?*

$$E(Y(a,p,c)) = \eta^* + \alpha^* \cdot a + \beta^* \cdot p + \theta^* \cdot c$$

$$E\left(Y\left(c_a, c_p, c_c\right)\right) = \eta' + \alpha' \cdot c_a + \beta' \cdot c_p + \theta' \cdot c_c,$$

Figure 4
Hypothetical Age–Period–Cohort Model With Intervening Mechanisms



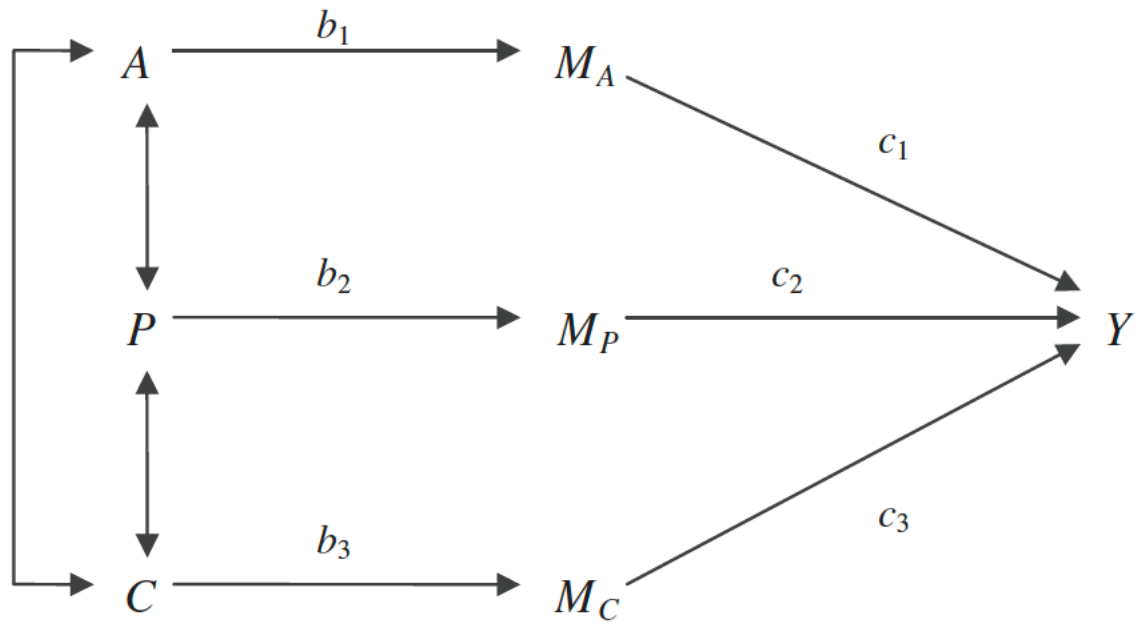
Bijlsma et al. (2017). An assessment and extension of the mechanism-based approach to the identification of age-period-cohort models. Link
Winship & Harding (2008). A mechanism-based approach to the identification of age-period-cohort models. Link

1. We cannot intervene on age, period, or cohort, so we need to rely on observational data.

2. The variables of interest are in a deterministic relationship:

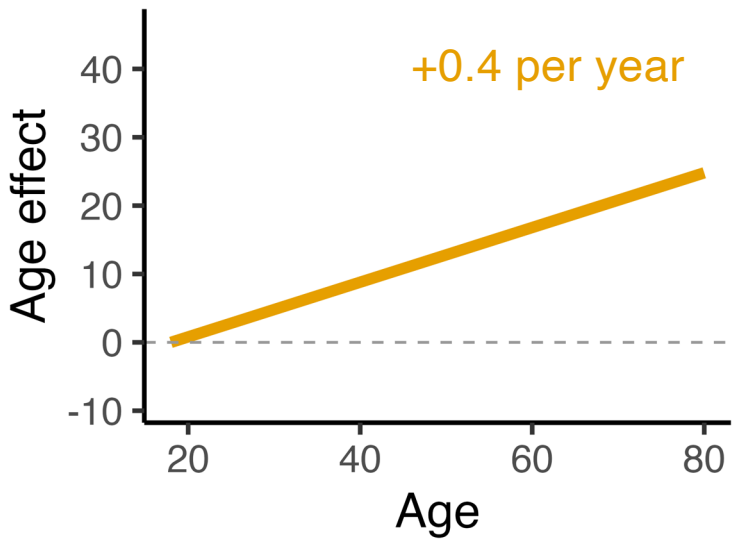
Age = Period − Cohort

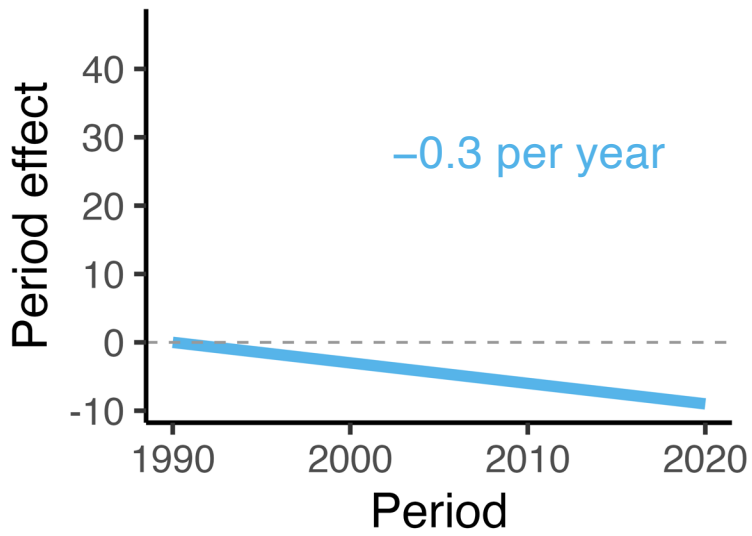
Figure 4
Hypothetical Age–Period–Cohort Model With Intervening Mechanisms

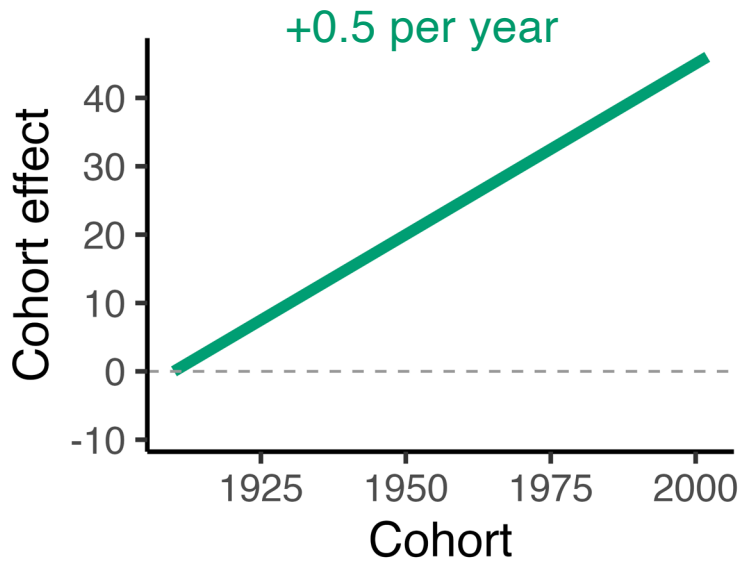


Bijlsma et al. (2017). An assessment and extension of the mechanism-based approach to the identification of age-period-cohort models. Link
Winship & Harding (2008). A mechanism-based approach to the identification of age-period-cohort models. Link

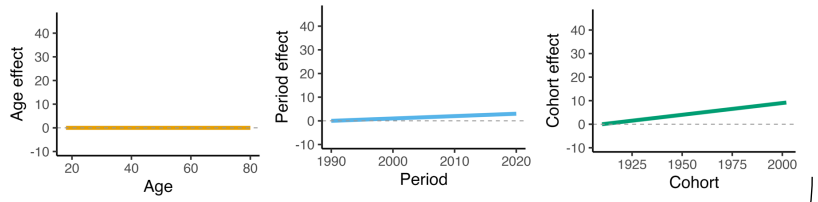
A simulated example





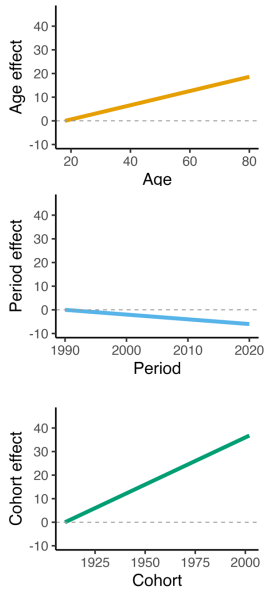


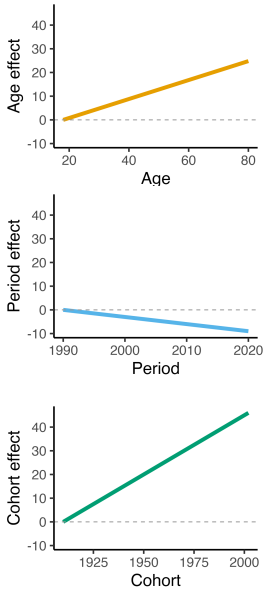
Age effect of 0
Period effect of 0.1
Cohort effect of 0.1

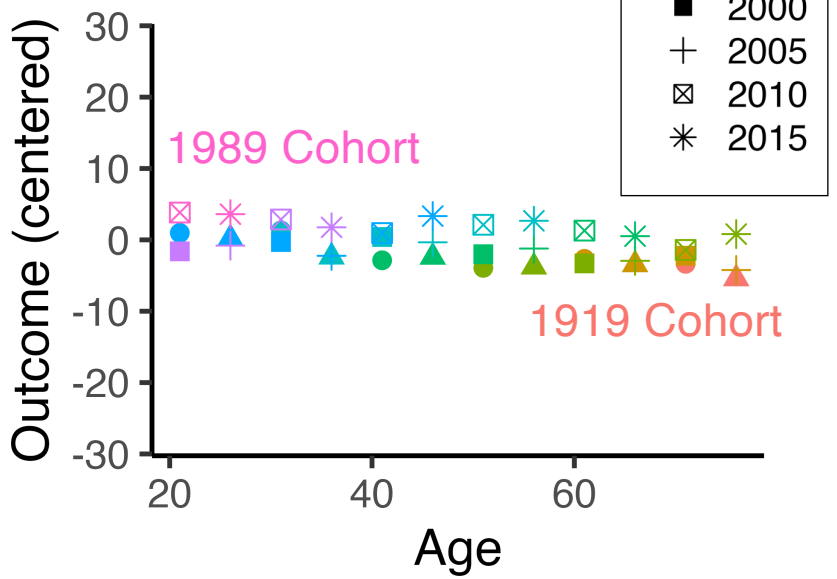


But the following effects are equally compatible with the observed mean pattern:

Age effect of +0.3
Period effect of −0.2
Cohort effect of +0.4

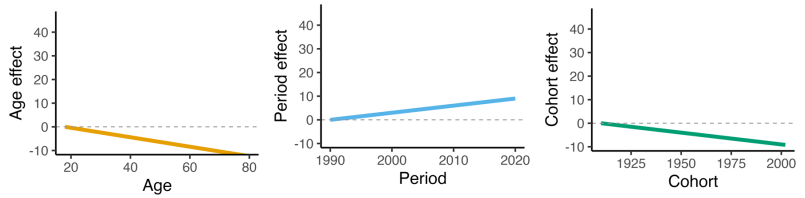






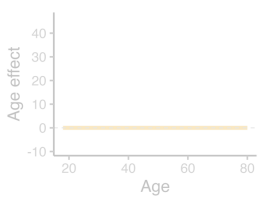
Effects that were used to generate the mean pattern:

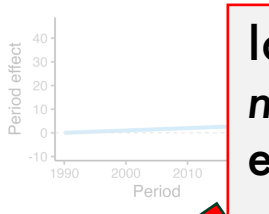
Age effect of +0.4
Period effect of −0.3
Cohort effect of +0.5

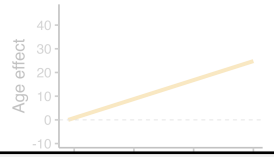


Age effect of −0.2
Period effect of 0.3
Cohort effect of −0.1

Age effect of 0
Period effect of 0.1
Cohort effect of 0.1







Age-Period-Cohort Identification Problem:
The observed pattern of means fits an infinite number of combinations of age, period, and cohort effects equally well.

So, based on the data alone, it is impossible to identify which combination of effects generated the observed data.

Identification problem means that it is *not* „just" a problem of statistical estimation

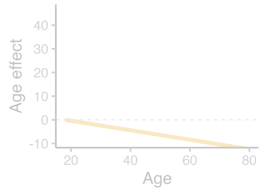
→ It applies regardless of how much data are available to us
→ It even applies if we have the full population available

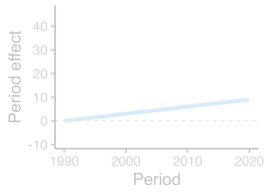
The problem applies regardless of the design with which we collected the data:
Cross-sectional design, repeated cross-sections, longitudinal design with a single cohort, longitudinal design with multiple cohorts („accelerated longitudinal design")…

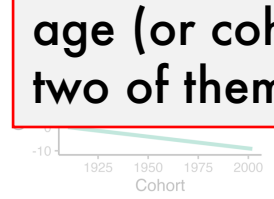
The problem applies regardless of whether we are interested „only" in age (or cohort or period) effects, or two of them, or all three of them.

Effects that were used to generate the mean pattern:

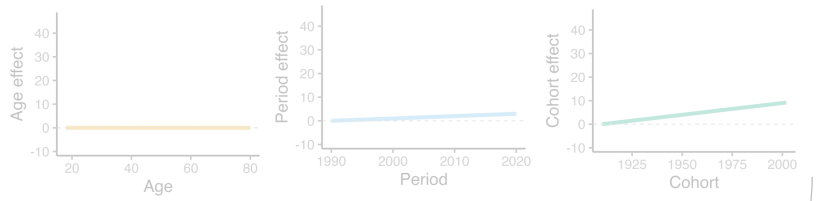
Age effect of +0.4
Period effect of −0.3
Cohort effect of +0.5







Age effect of 0
Period effect of 0.1
Cohort effect of 0.1



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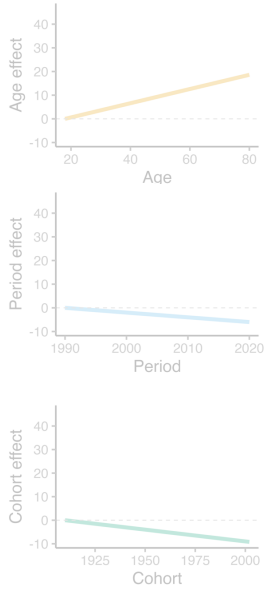

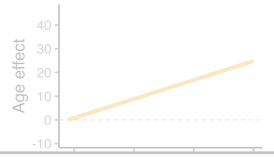

Age-Period-Cohort Identification Problem:

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identify which combination of effe
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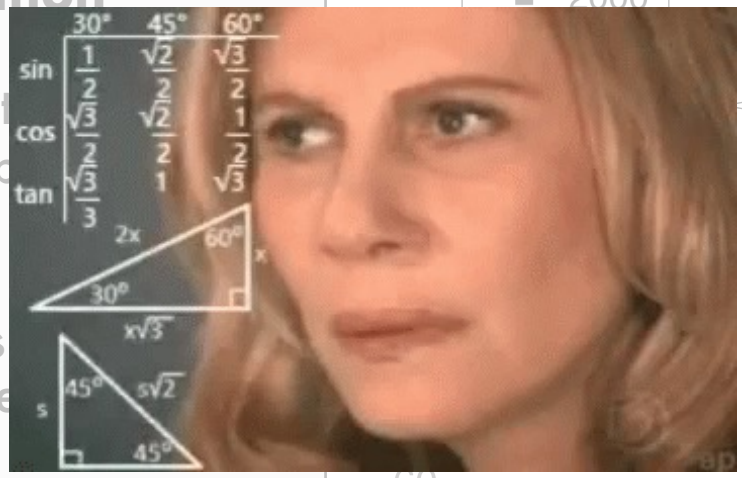
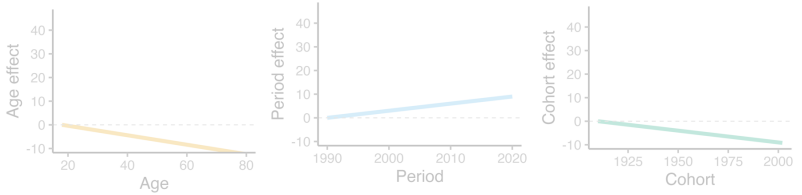


60

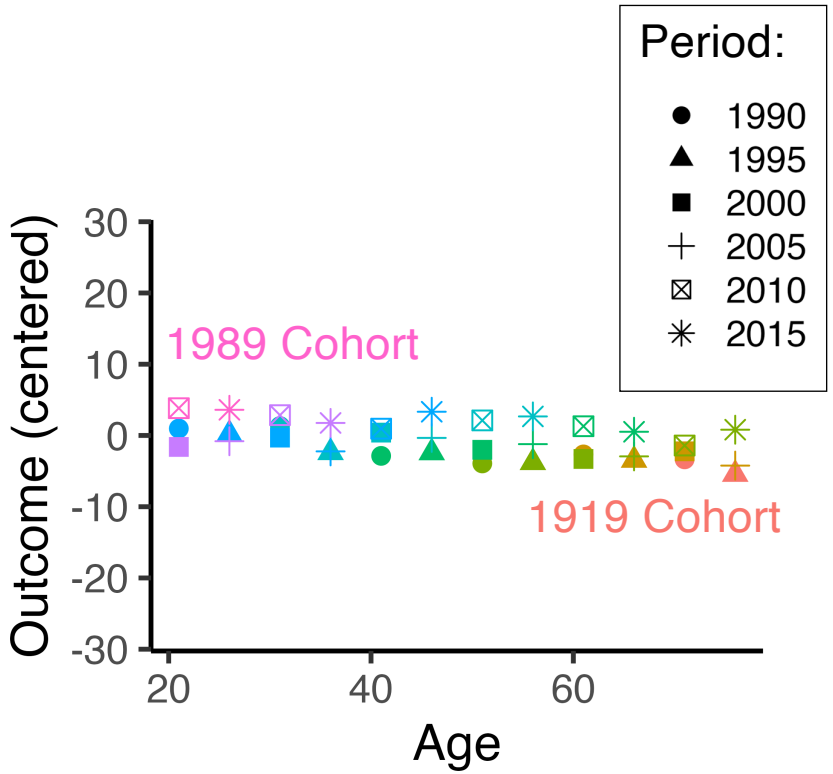
Age

Effects that were used to generate the mean pattern:

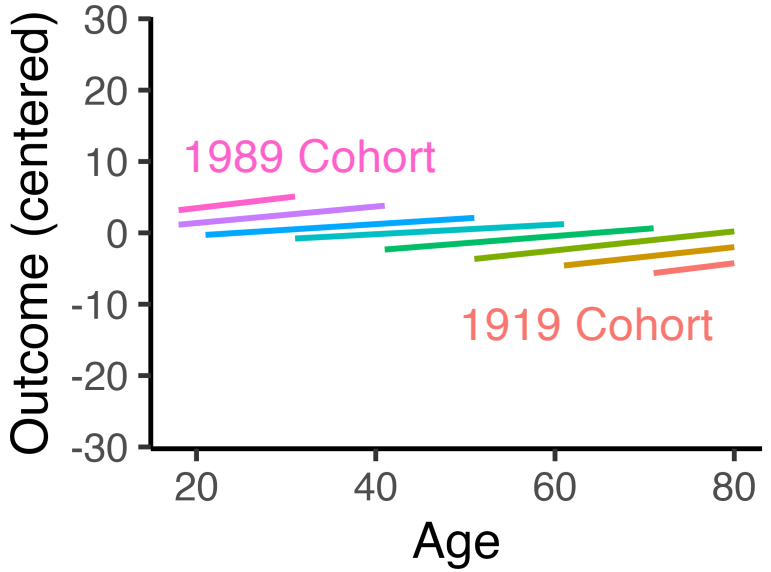
Age effect of +0.4
Period effect of −0.3
Cohort effect of +0.5



Age effect of −0.2
Period effect of 0.3
Cohort effect of −0.1



Connect cohortwise



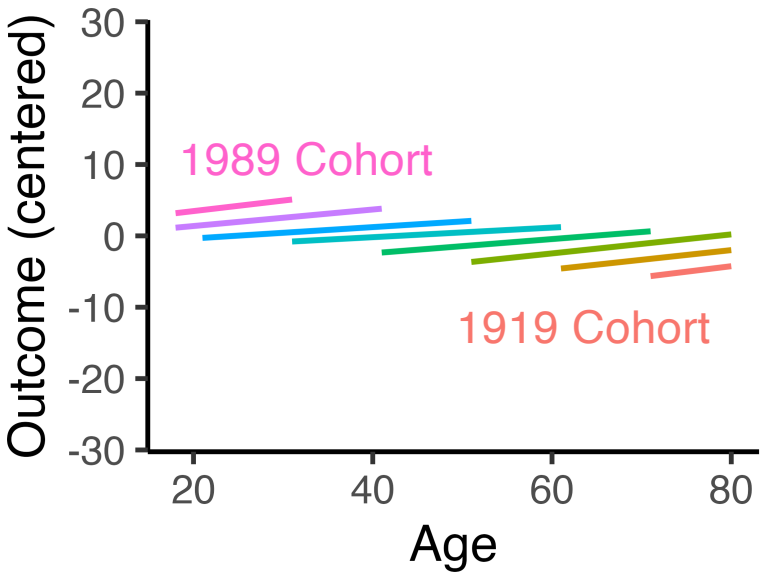
Age effect + period effect = 0.1

Slope of the lines: 0.1 per year

When a cohort ages by one year, both age and period increase by one.

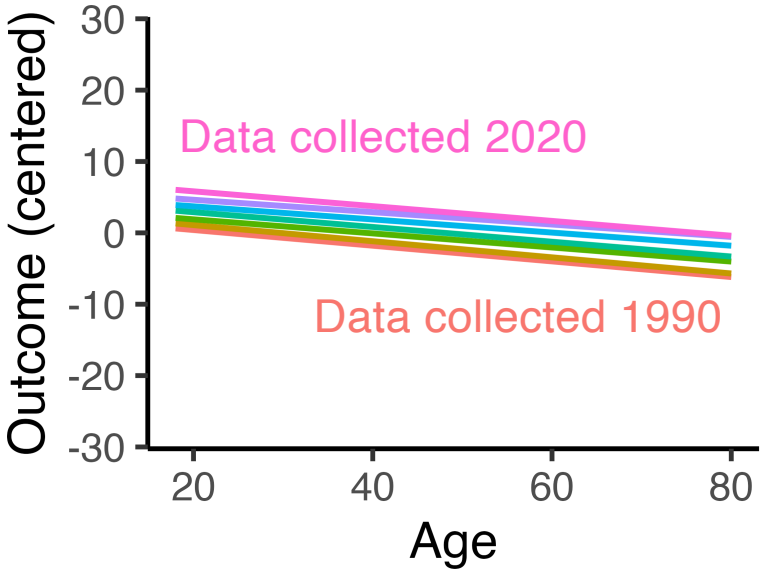
So, the increase over one year is the sum of the age effect over one year and the period effect over one year.

Connect cohortwise



Age effect + period effect = 0.1

Connect periodwise



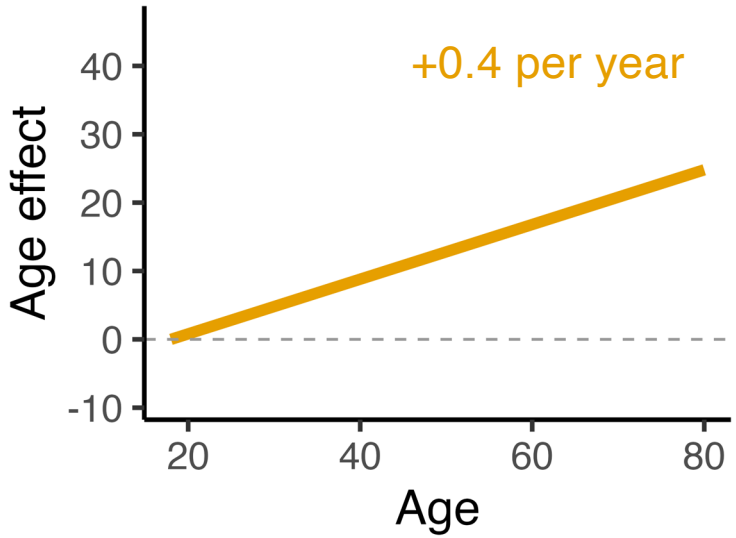
Age effect − cohort effect = −0.1

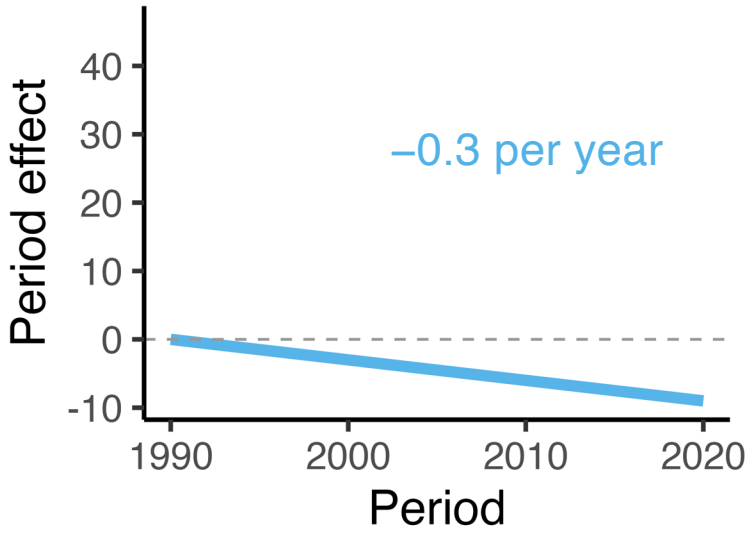
Slope of the lines: −0.1 per year

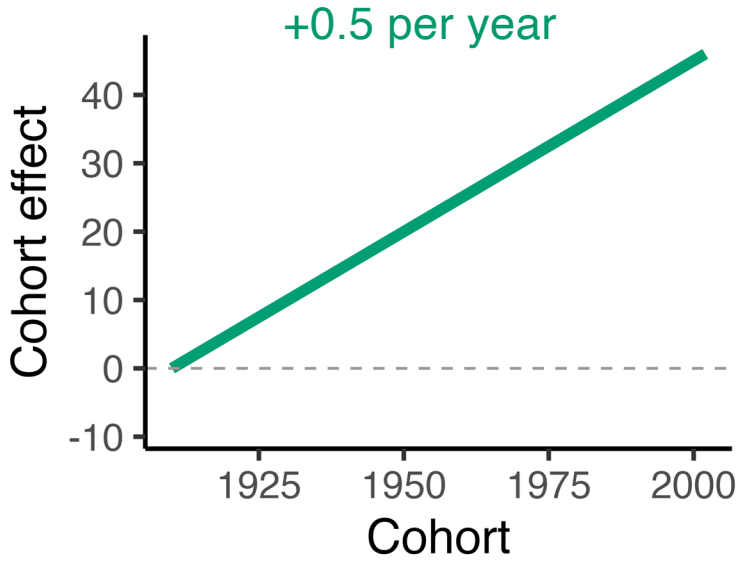
In a given year, a person who is one year older (age +1) was born one cohort earlier (cohort −1)

So, the increase over one year is the age effect over one year minus the cohort effect over one year

Quick sanity check



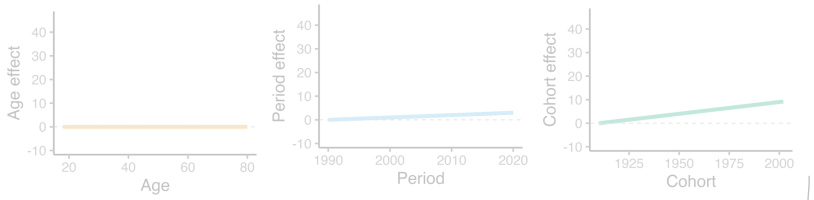




Age effect + period effect
= 0.1

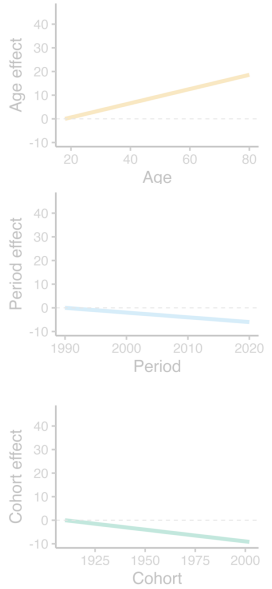
Age effect − cohort effect
= −0.1

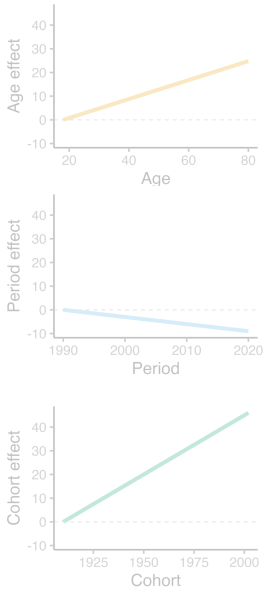
Age effect of 0
Period effect of 0.1
Cohort effect of 0.1



But the following effects are equally compatible with the observed mean pattern:

Age effect of +0.3
Period effect of −0.2
Cohort effect of +0.4

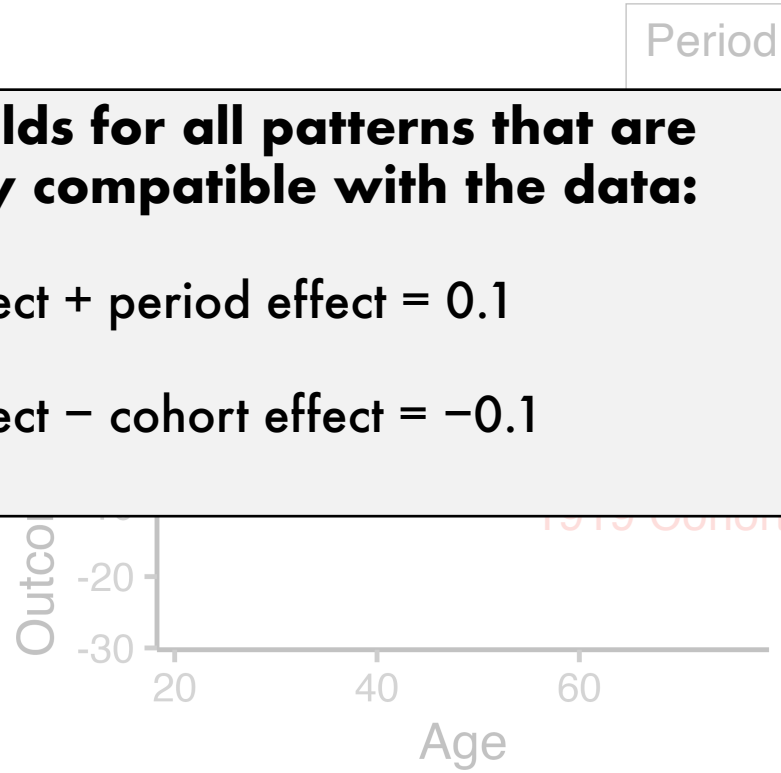




This holds for all patterns that are equally compatible with the data:

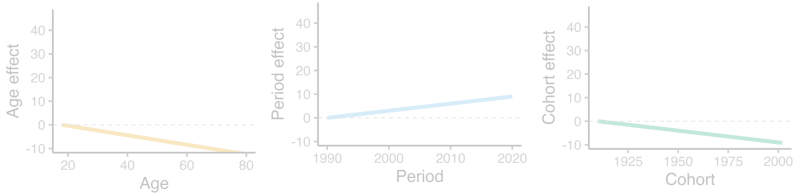
Age effect + period effect = 0.1

Age effect − cohort effect = −0.1



Effects that were used to generate the mean pattern:

Age effect of +0.4
Period effect of −0.3
Cohort effect of +0.5

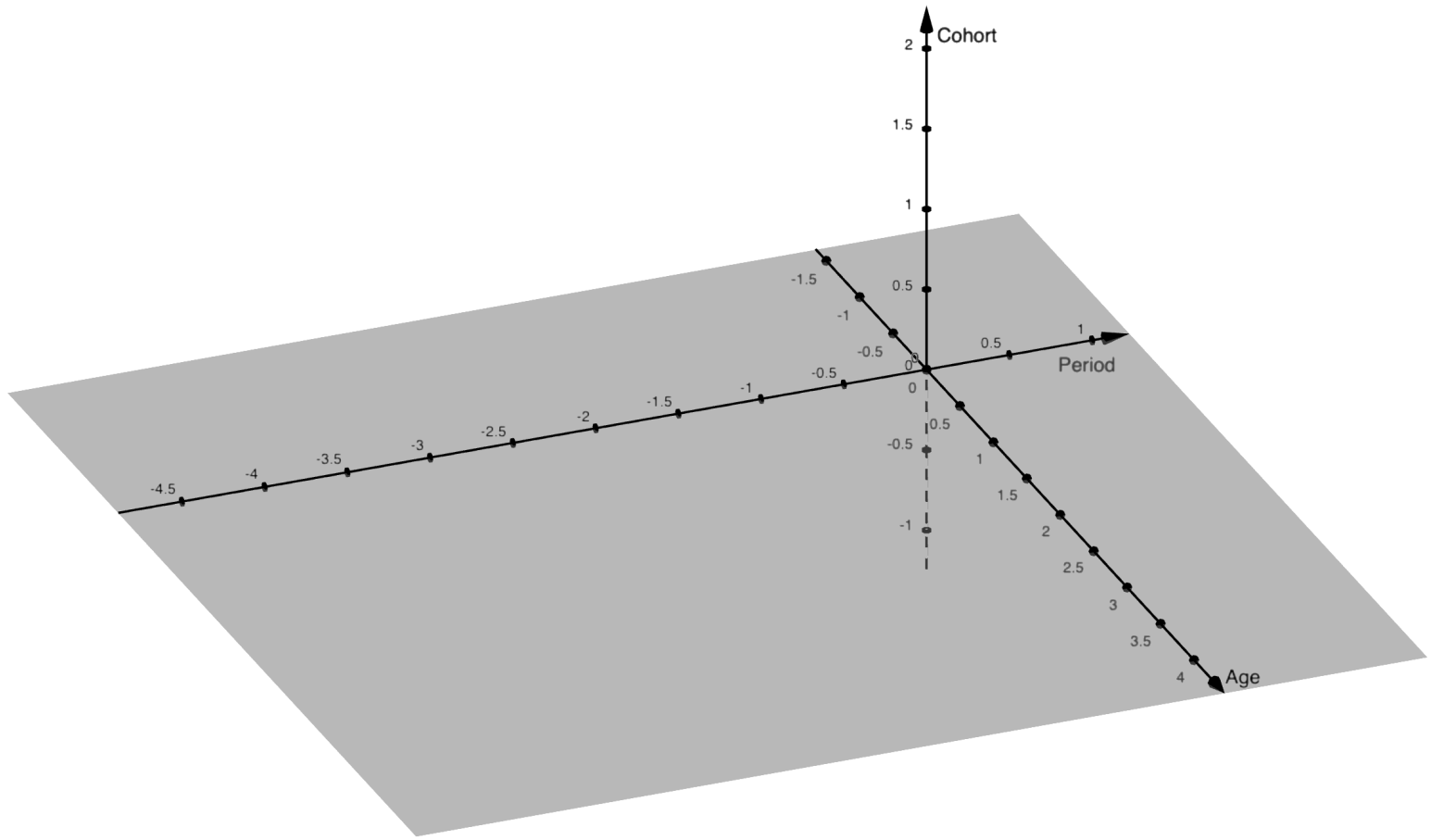


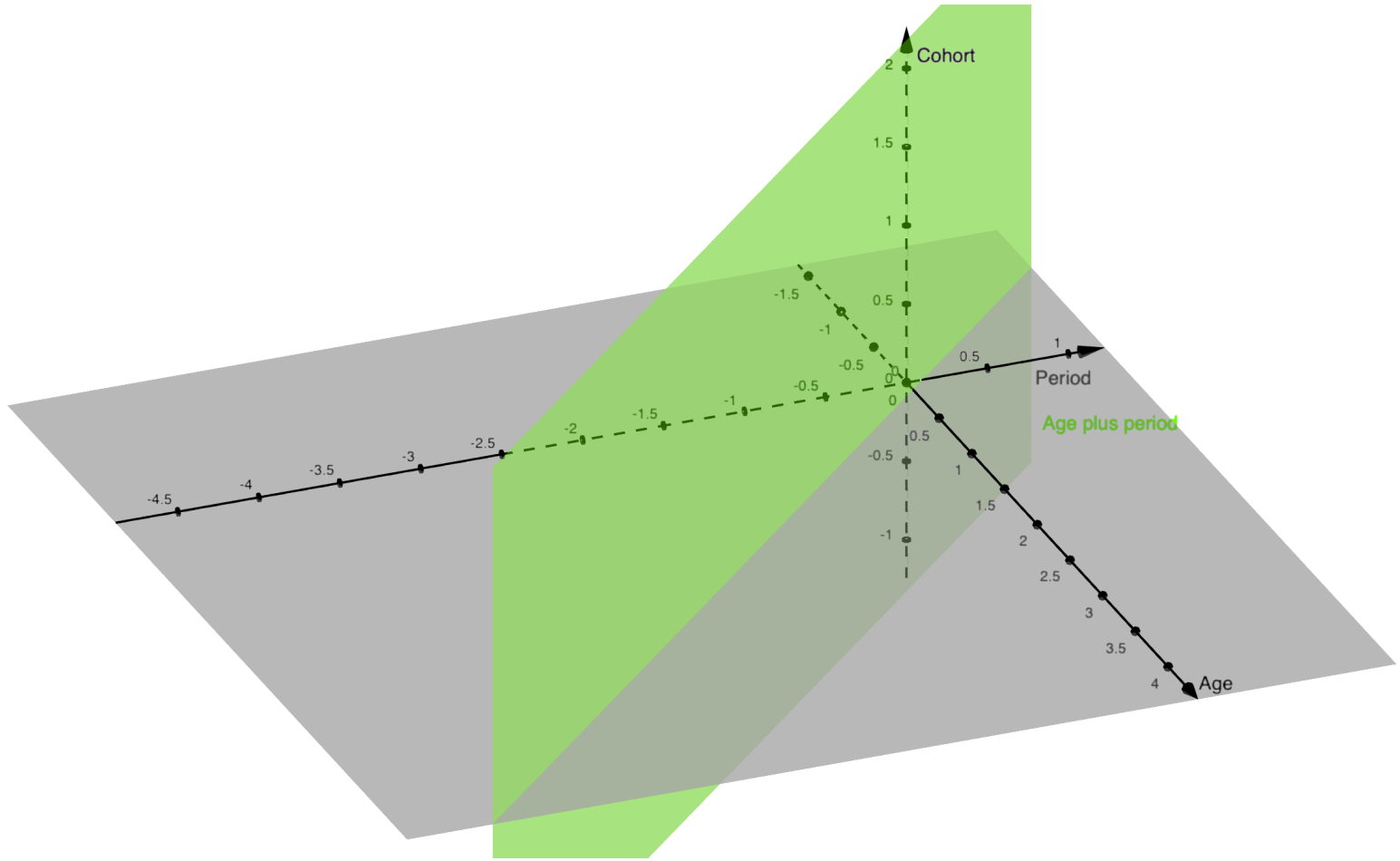
Age effect of −0.2
Period effect of 0.3
Cohort effect of −0.1

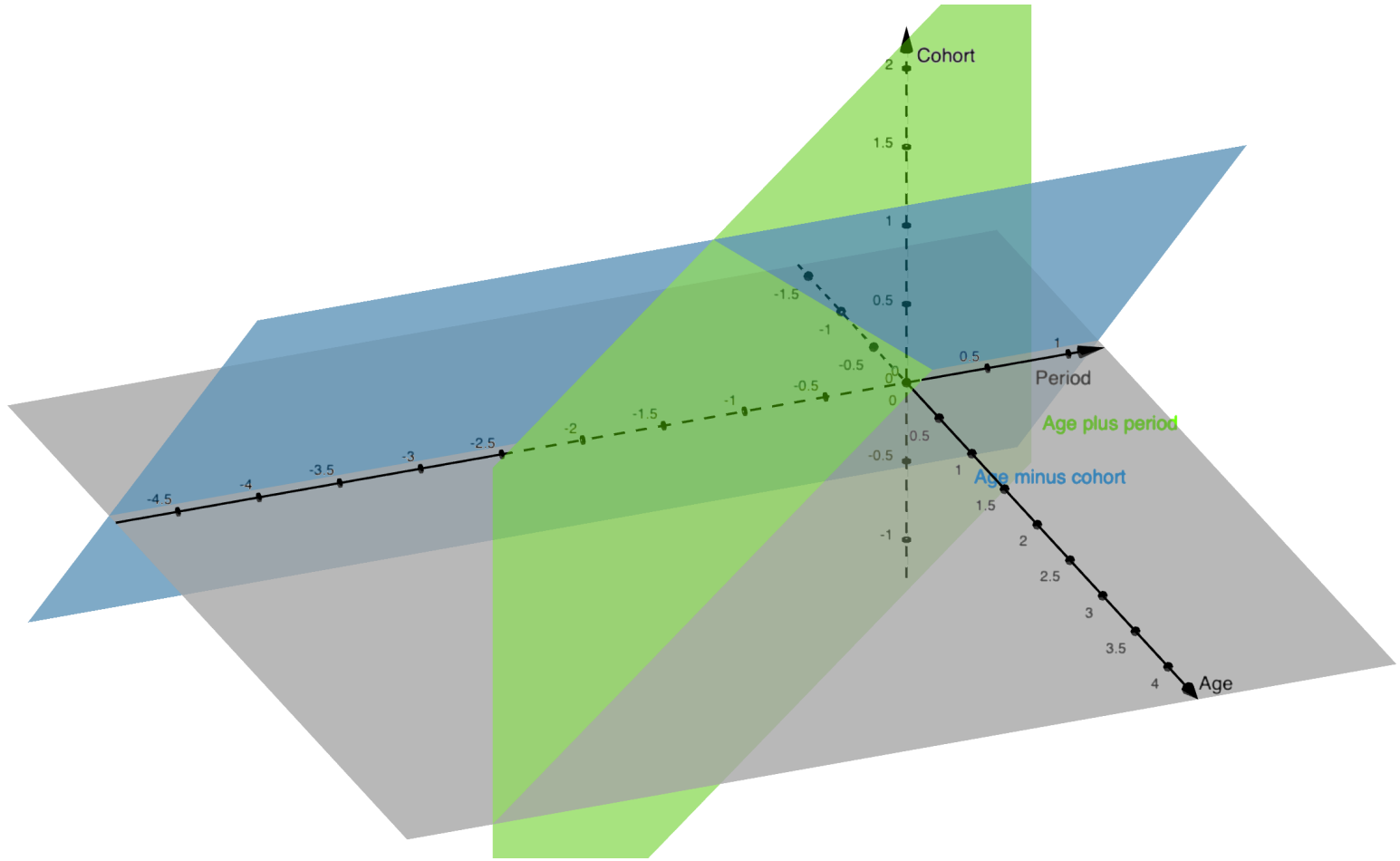
Solutions to the age-period-cohort problem

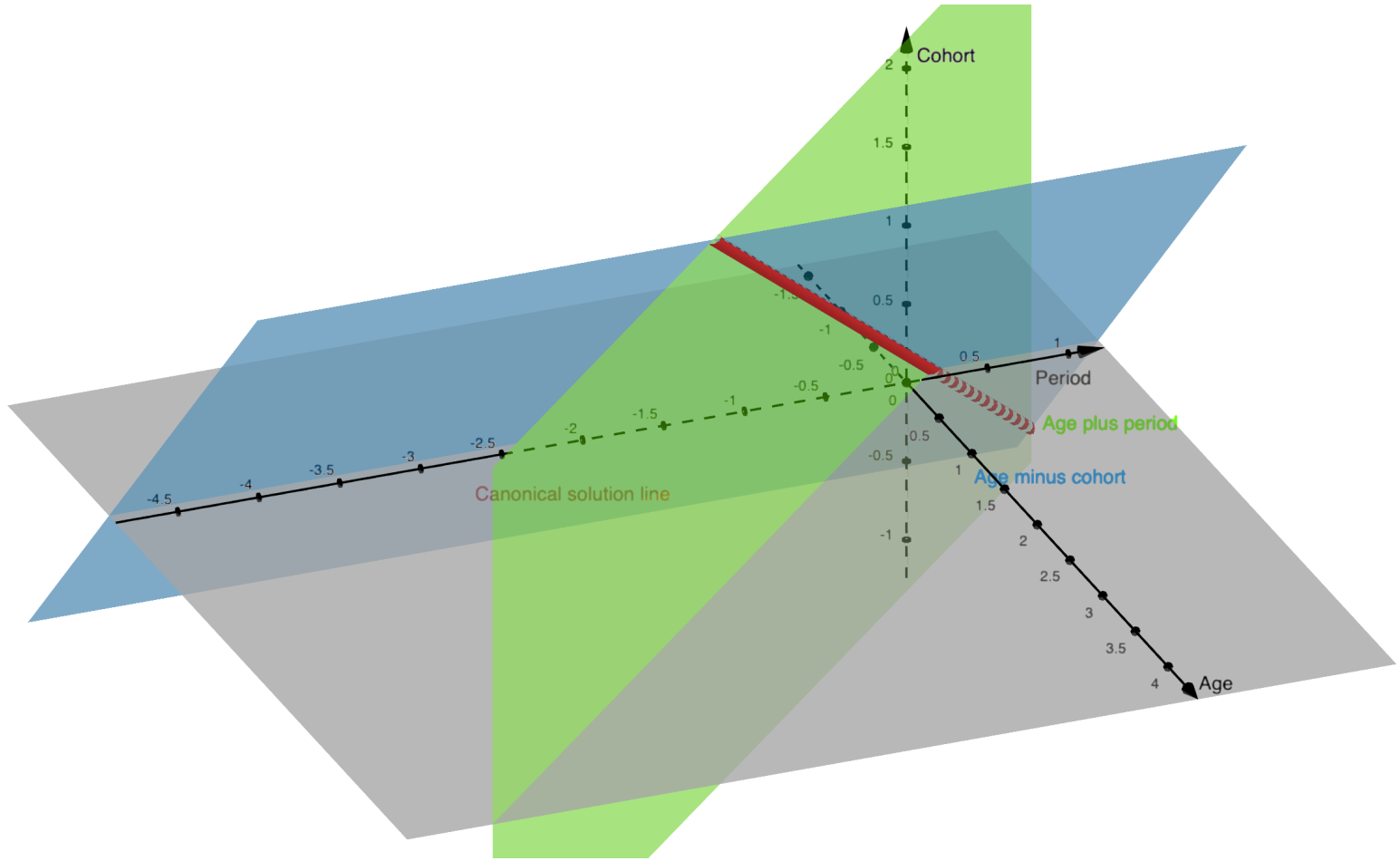
(Fosse & Winship, 2018, 2019)

- We *cannot* learn the age, period, and cohort effects from the data (because an infinite number of combinations of them are equally compatible with the data)
- However, we can learn combinations of them
  - For example
    - Age effect + period effect = 0.1
    - Age effect − cohort effect = −0.1
- This limits the space of solutions compatible with the data

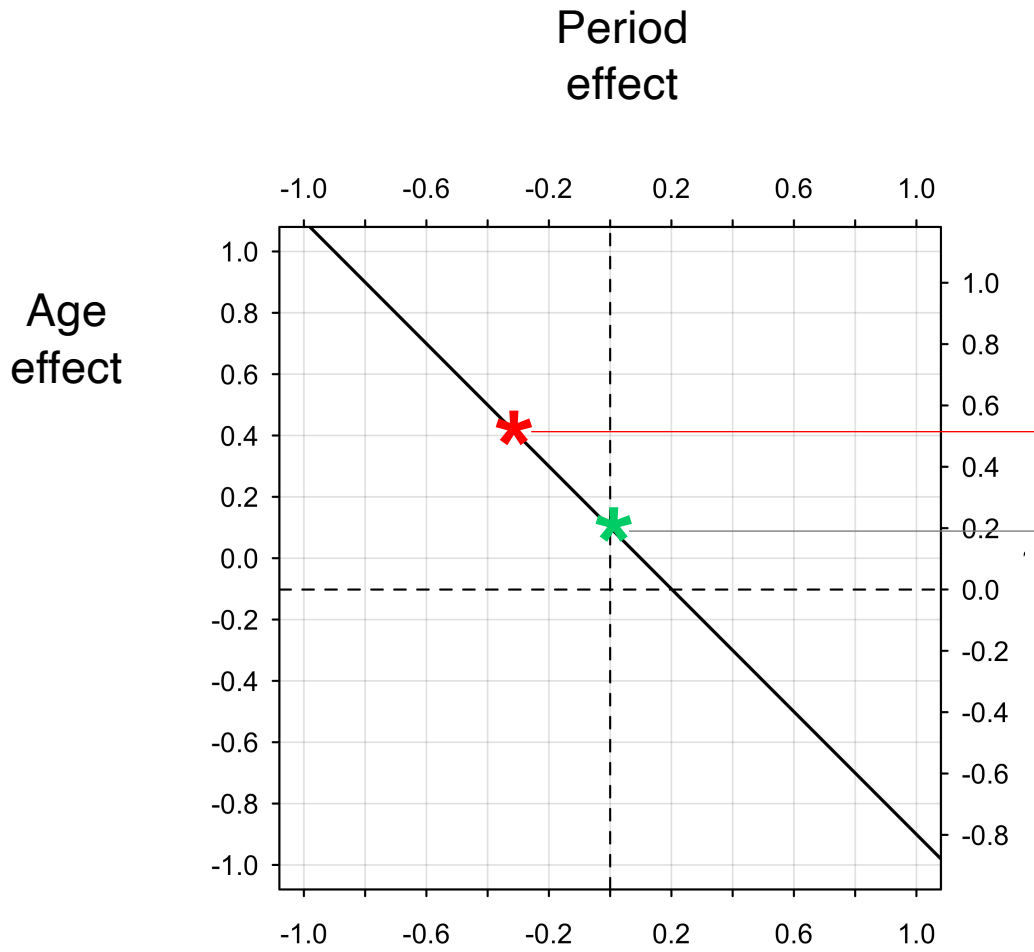

Cohort
2
1.5
1
0.5
0
-0.5
-1
Period
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
Age
0.5
1
1.5
2
2.5
3
3.5
4


Cohort
2
1.5
1
0.5
0
-0.5
-1
-1.5
Period
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
Age plus period
Age
0.5
1
1.5
2
2.5
3
3.5
4


Cohort
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
Period
0.5
1
Age plus period
Age minus cohort
0.5
1
1.5
2
2.5
3
3.5
4
Age

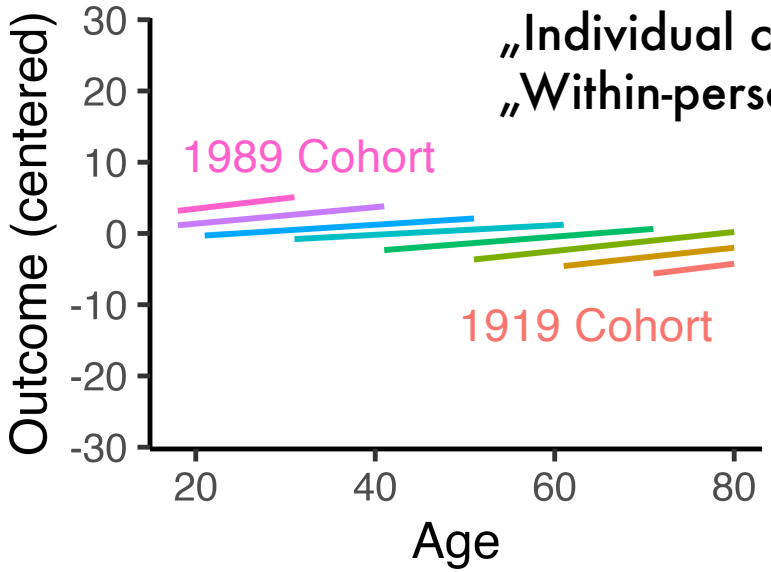

Cohort
Period
Age
Age plus period
Age minus cohort
Canonical solution line

Canonical solution line in 2D



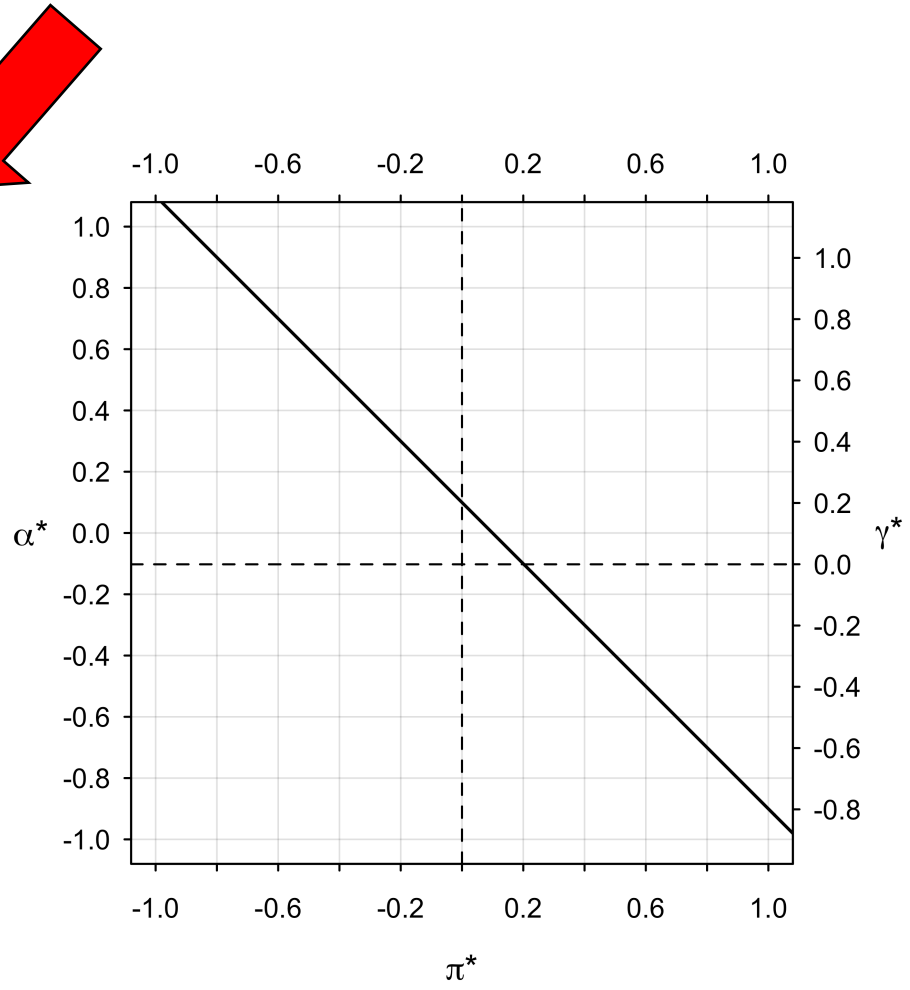
Correct solution
Age: 0.4 points per year
Period: –0.3 points per year
Cohort: 0.5 points per year

If the period effect is zero
Age: 0.1 points per year
Period: 0
Cohort: 0.2 points per year



Canonical solution line

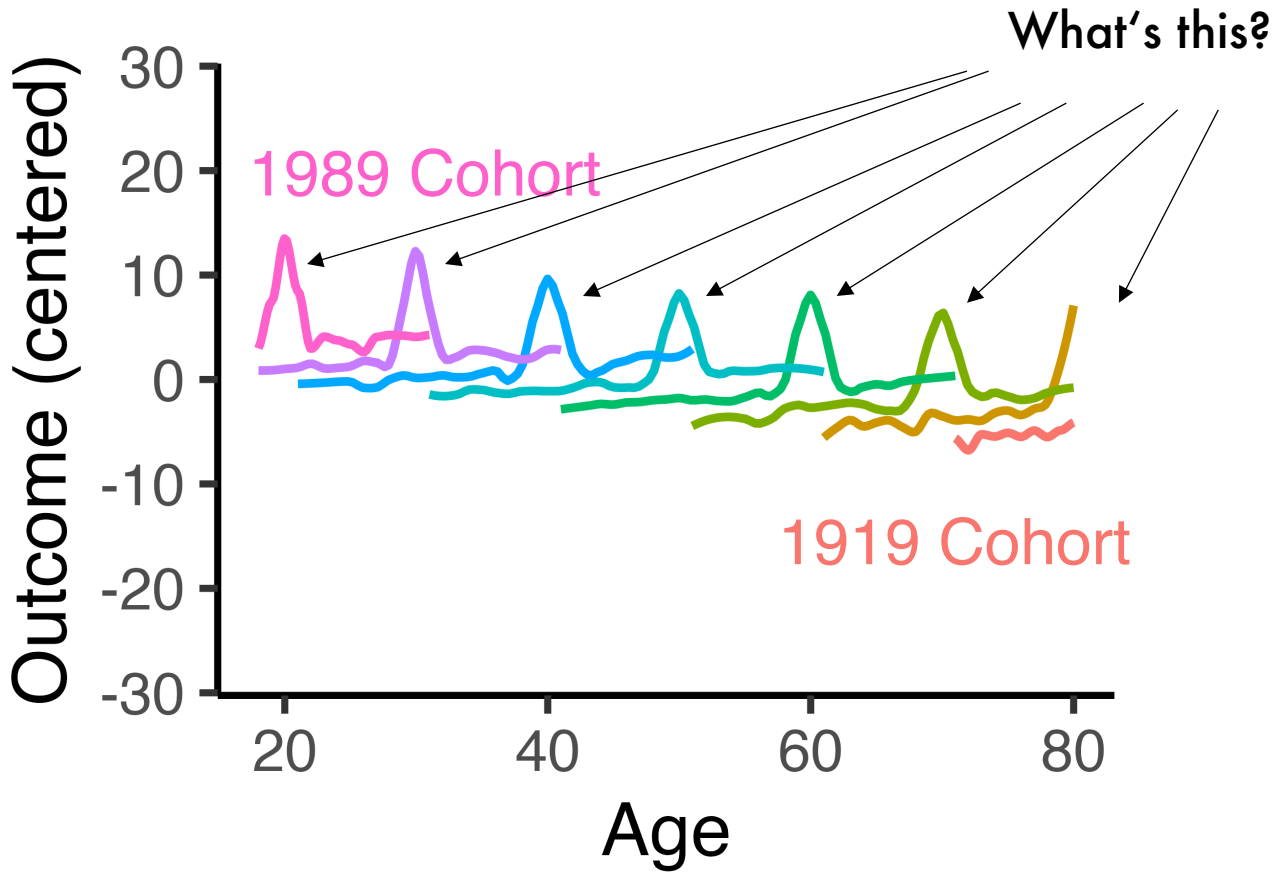
- Line that depicts all combinations of linear age, period, and cohort effects that are compatible with the data
- This already tells us some things just based on the data alone
  - In our example, for example
    - If the age effect is positive, then the cohort effect is also positive
    - It's not possible that both the age and the period effect are negative



What about non-linear effects?

- An assumption that I have hidden from you so far: throughout, we are assuming that age, period, and cohort do not interact
- It turns out that under this assumption, we *can* actually identify nonlinearities in the age, period, and cohort effects *from the data alone*

What about non-linear effects?



If it were a non-linear age effect, it would occur at the same age in each cohort.

If it were a non-linear cohort effect, it would shift the line of one cohort but not affect the other cohorts.

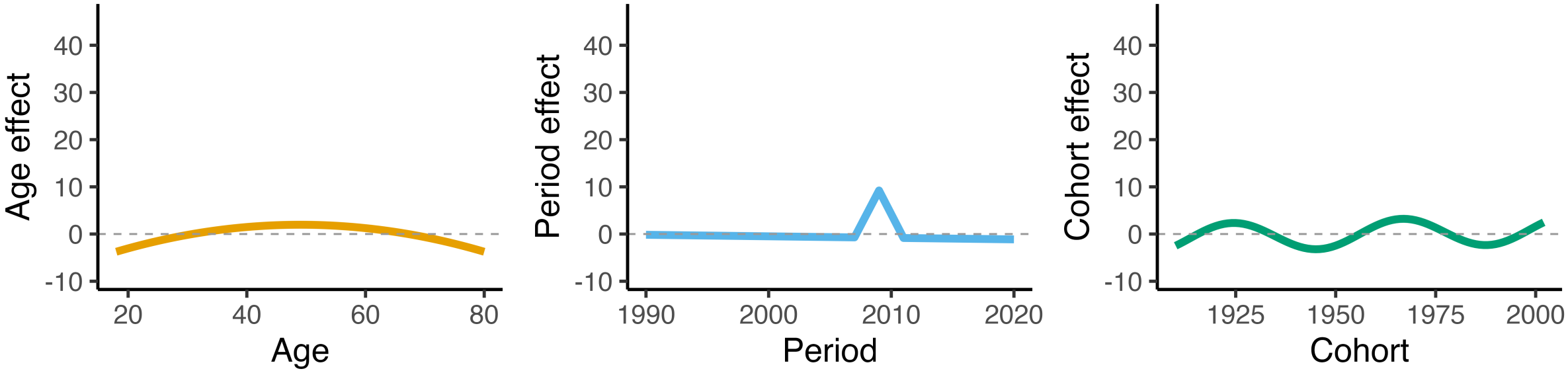
→ It must be a period non-linearity!

(Period-peak from 2008 to 2010)

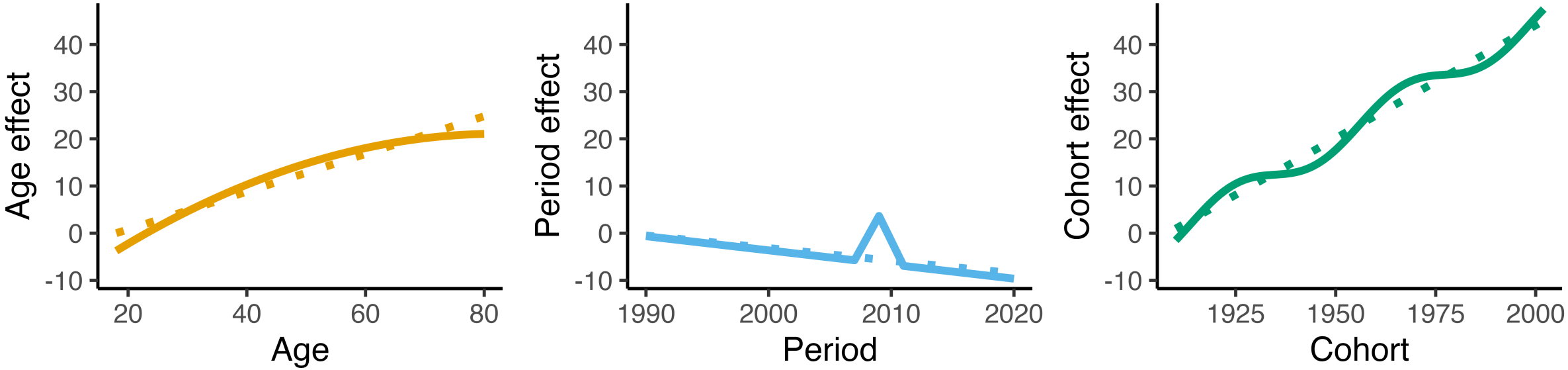
What about non-linear effects?

» Importantly, we can really *only* identify the nonlinear parts

The nonlinearities in isolation, which can be identified from the data

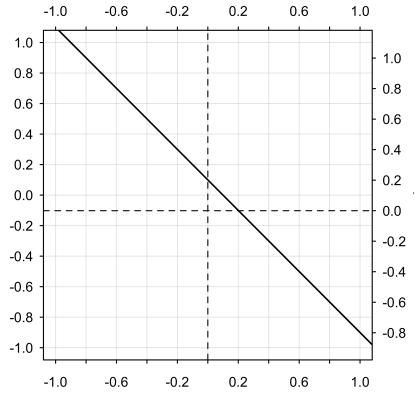


The interpretation of the nonlinearities depends on the linear effects



Now, what do we do with this?

1. Fit a linearized age-period-cohort model
   - » Linear model parametrized in a manner that it returns the canonical solution line plus the nonlinearities



2. Add assumptions, for example
   - » About the linear effects
   - » About the total effects
3. Plot the trajectories of the age, period, and cohort effects that are compatible with the data and the assumptions

Full article:
Thinking Clearly About Age, Period, and Cohort Effects

Thank you for your attention!