Visualization as a **design** process

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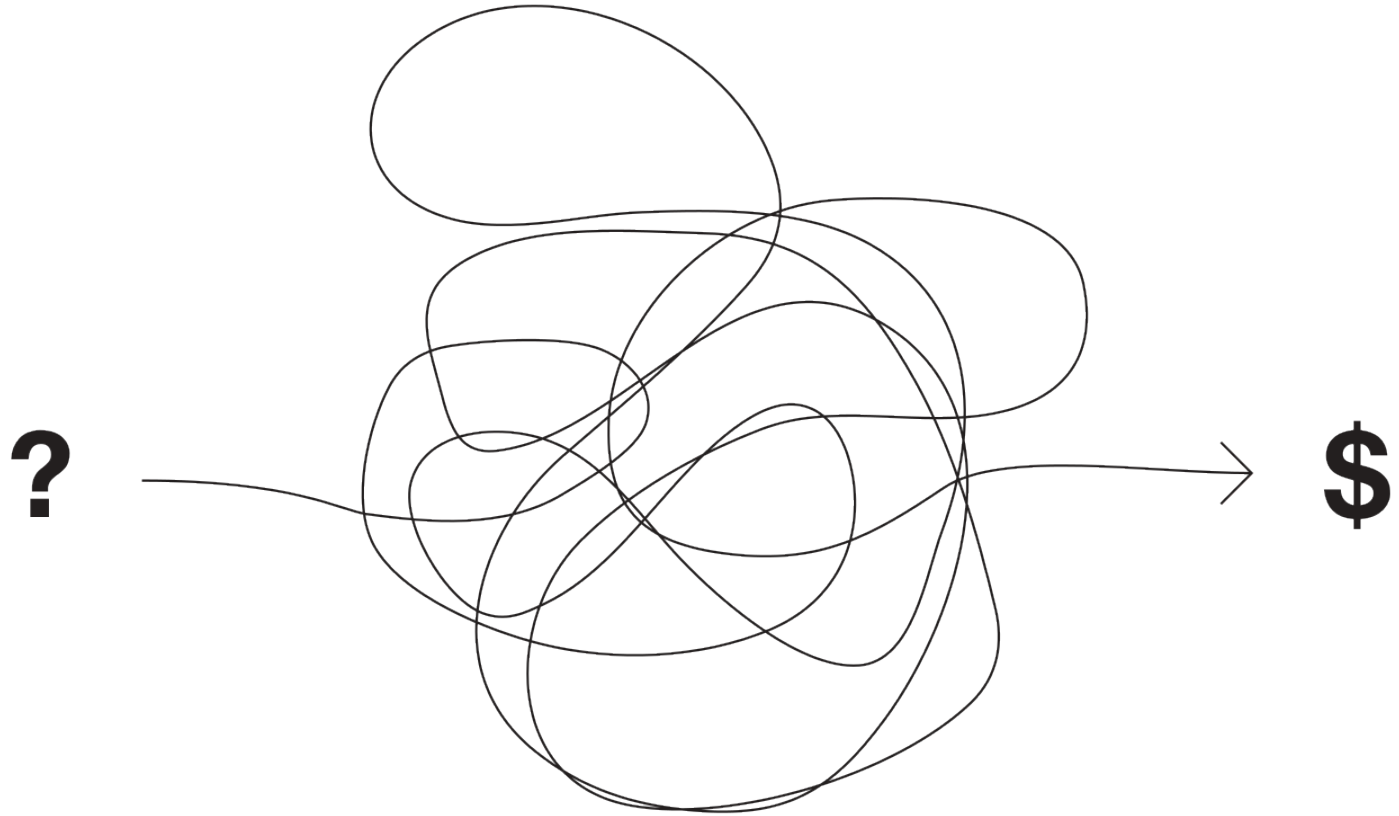
MAX PLANCK INSTITUTE
FOR DEMOGRAPHIC RESEARCH

What is a design process?



Tim Brennan (~1990) via Dubberly (2008). How do you design? A Compendium of Models.

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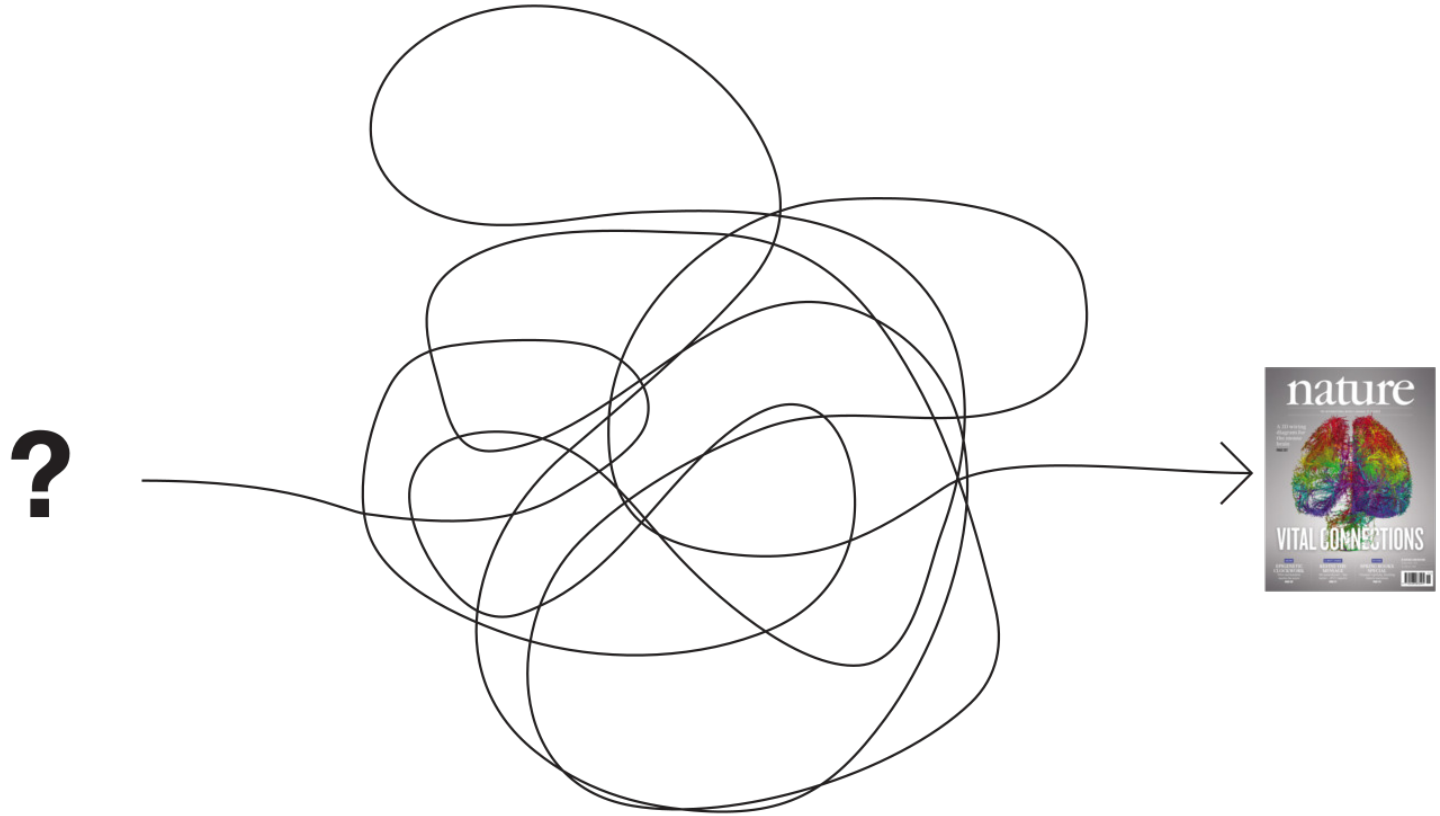
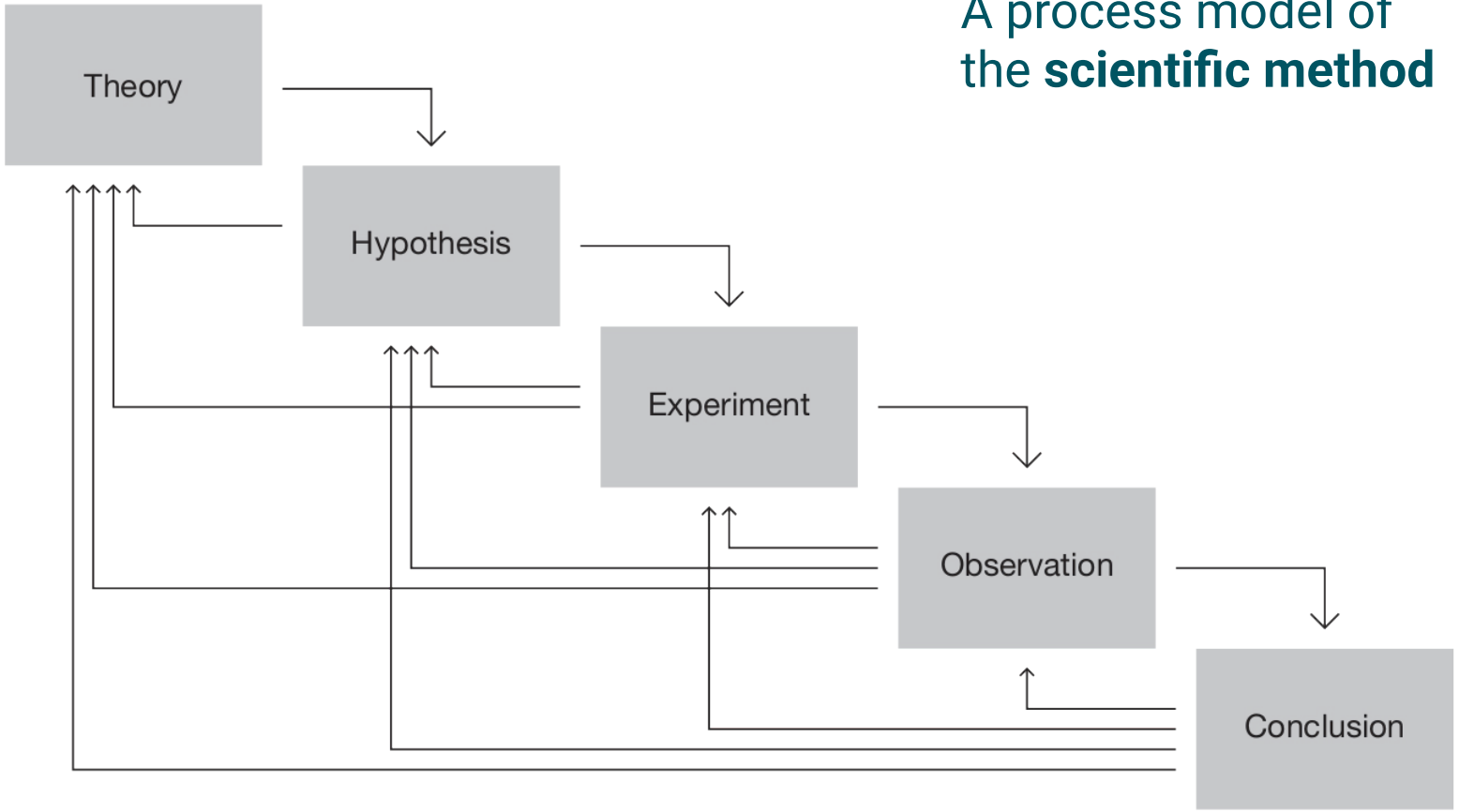


Tim Brennan (~1990) adapted for academia. How do you design? A Compendium of Models.

What is a design process?

A process model of
the **scientific method**



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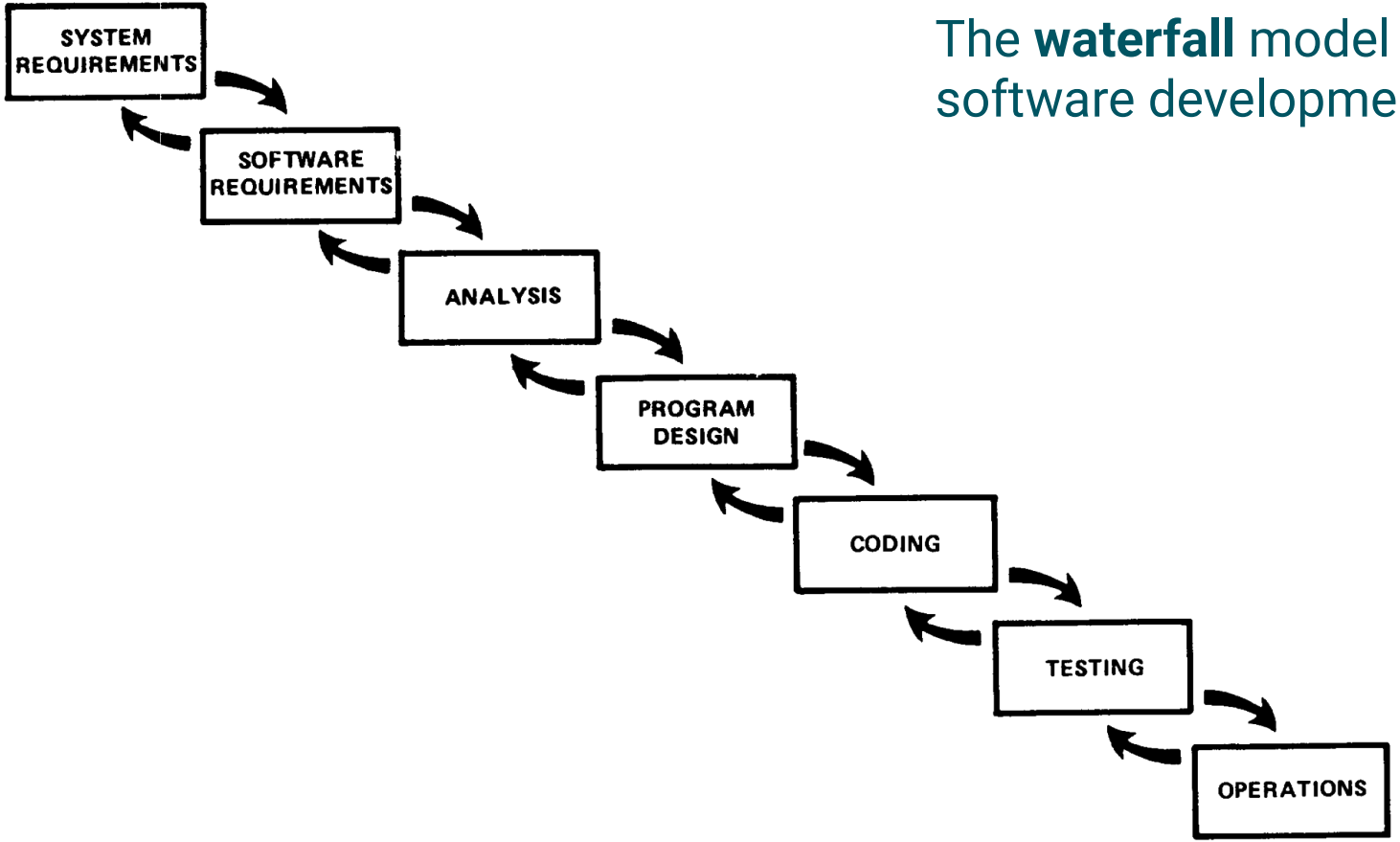
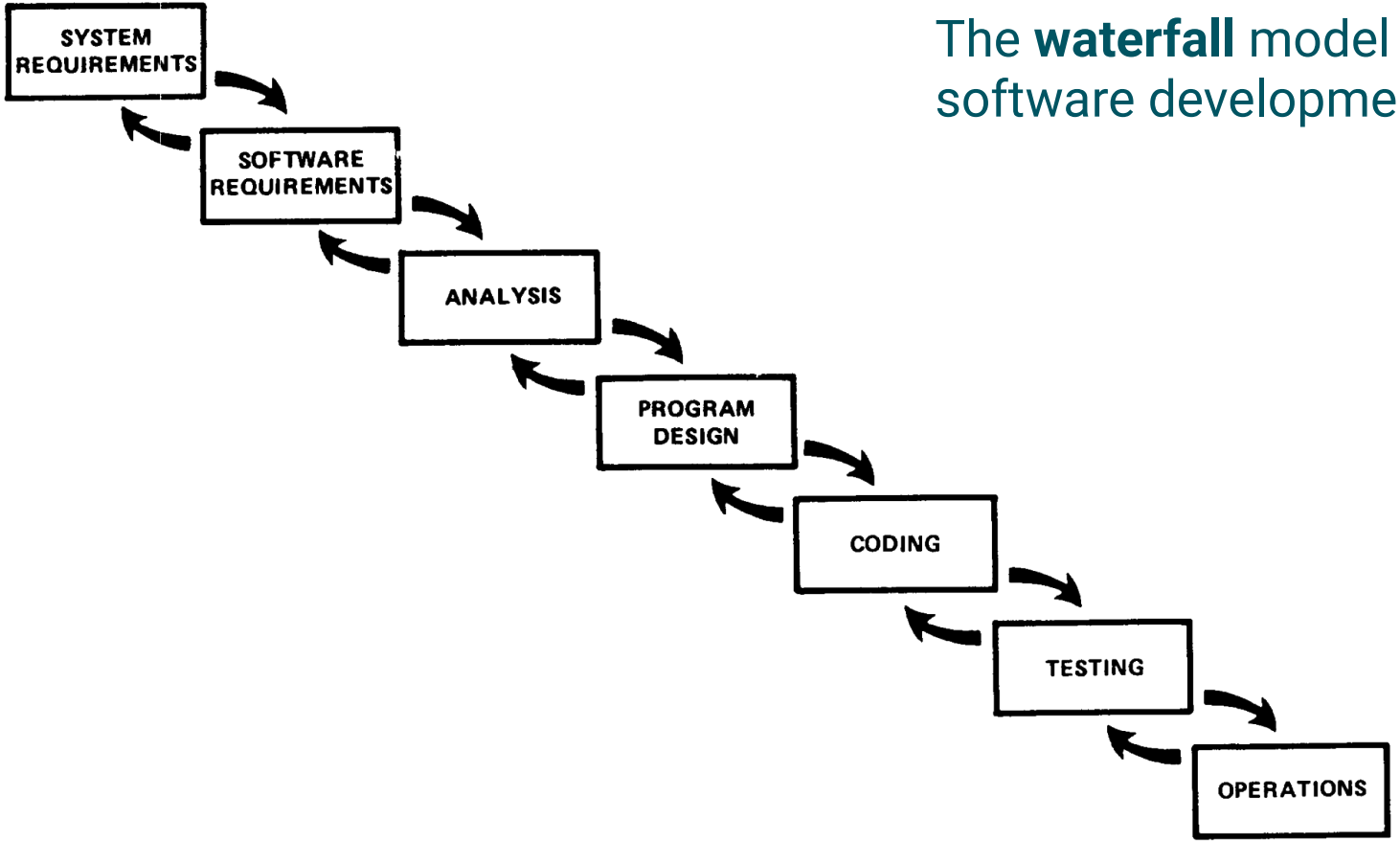


The **waterfall** model of software development

Royce, W. W. (1970). Managing the development of large software systems. 10.5555/41765.41801.

What is a design process?



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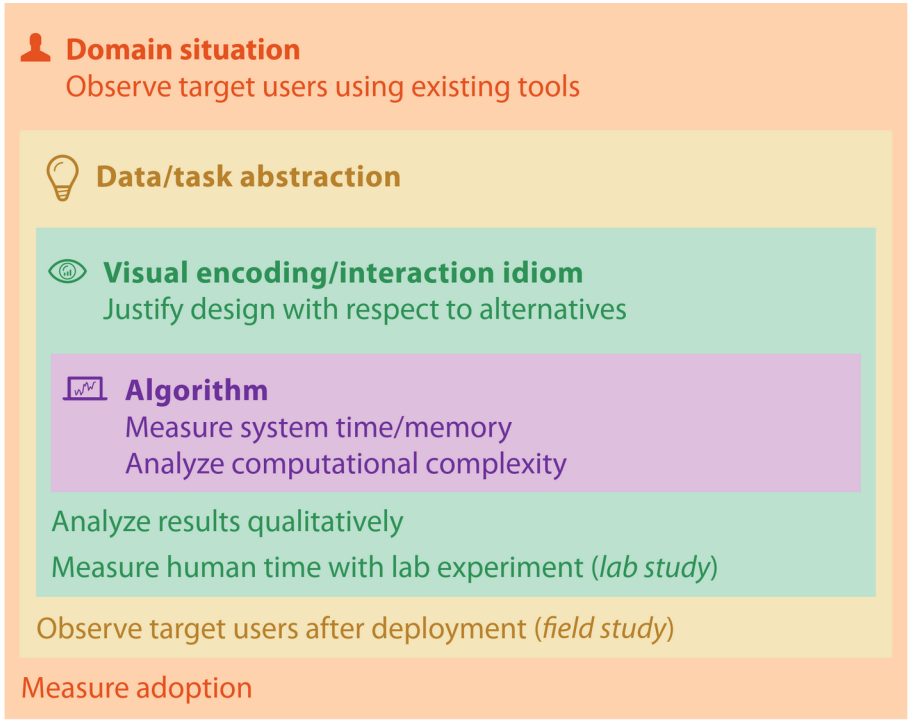
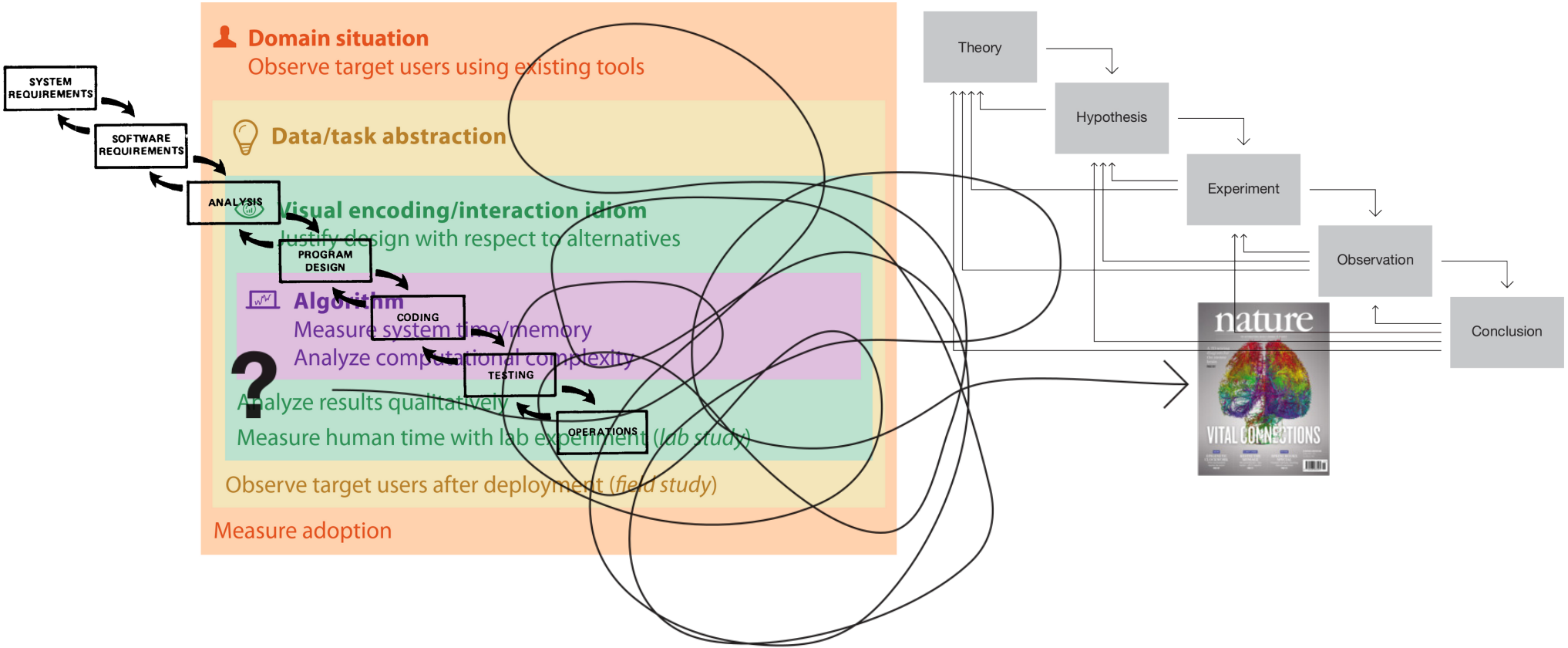


Four levels of **viz design**

Munzner (2015). Visualization analysis & design. Link.

What is a design process?



What is a design process?

Iteration until converging on a predefined goal

Iteration

Iteration as **global search**

2D/3D?

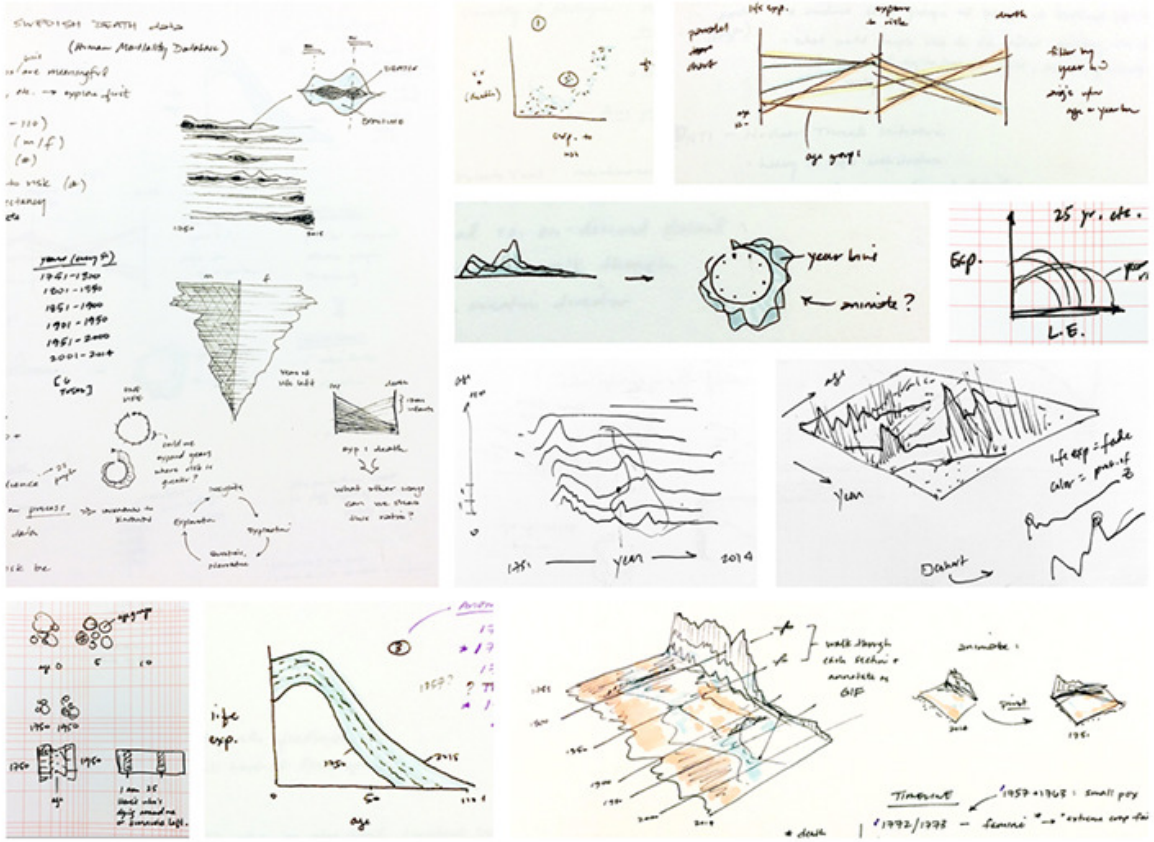
Raw/
Summaries?

Show age and
time evolution of
mortality sex gap

Points/Lines/
Shading?

Static/Animated?

Dense/sparse?



Periscopic (2017). Behind the Scenes: Visualizing 264 Years of Swedish Mortality.

Iteration

Iteration as **local refinement**

Show age and time evolution of mortality sex gap

2D/**3D**?

Raw/Summaries?

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Static/Animated?

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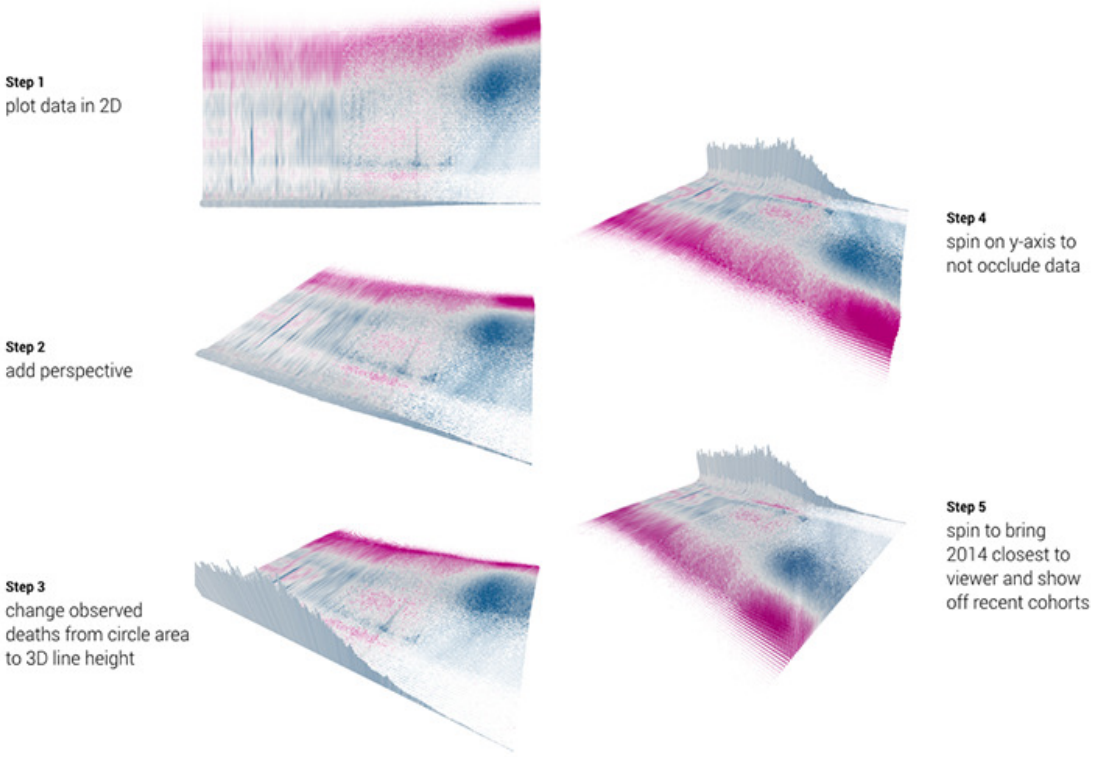
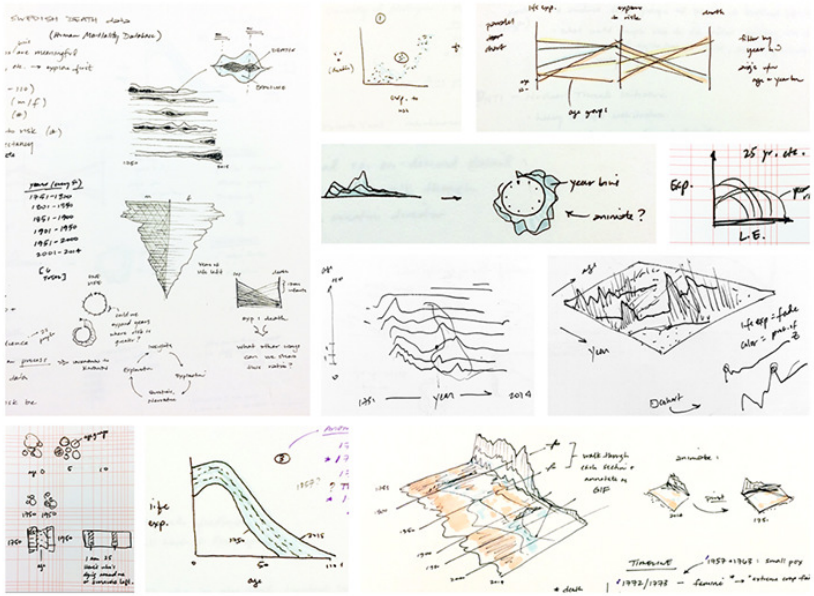
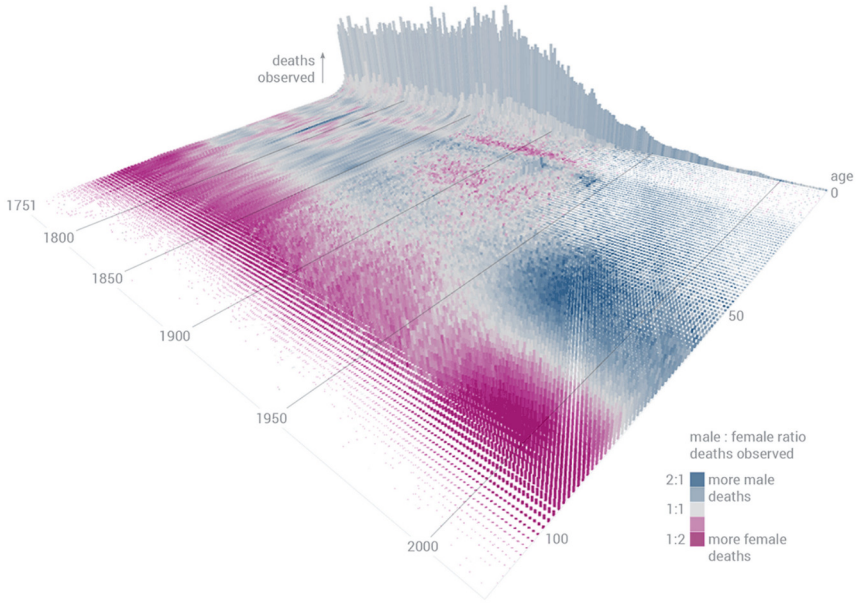


Periscopic (2017). Behind the Scenes: Visualizing 264 Years of Swedish Mortality.

Iteration

Iteration as **global search** → Iteration as **local refinement**





Since the 1980s, we see a rapid decline in male smoking with more women who now smoke daily. This is closing the gender gap in mortality.

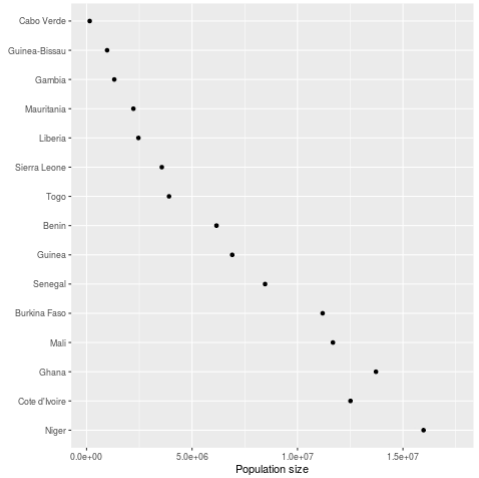
Periscopic (2017). Behind the Scenes: Visualizing 264 Years of Swedish Mortality.

Iteration

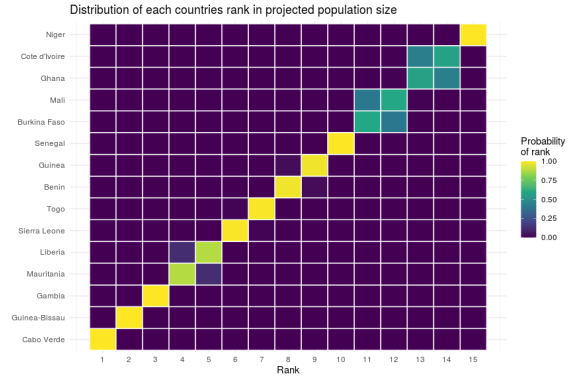
Iteration as **global search**

Show uncertainty in country ranking

Animated?



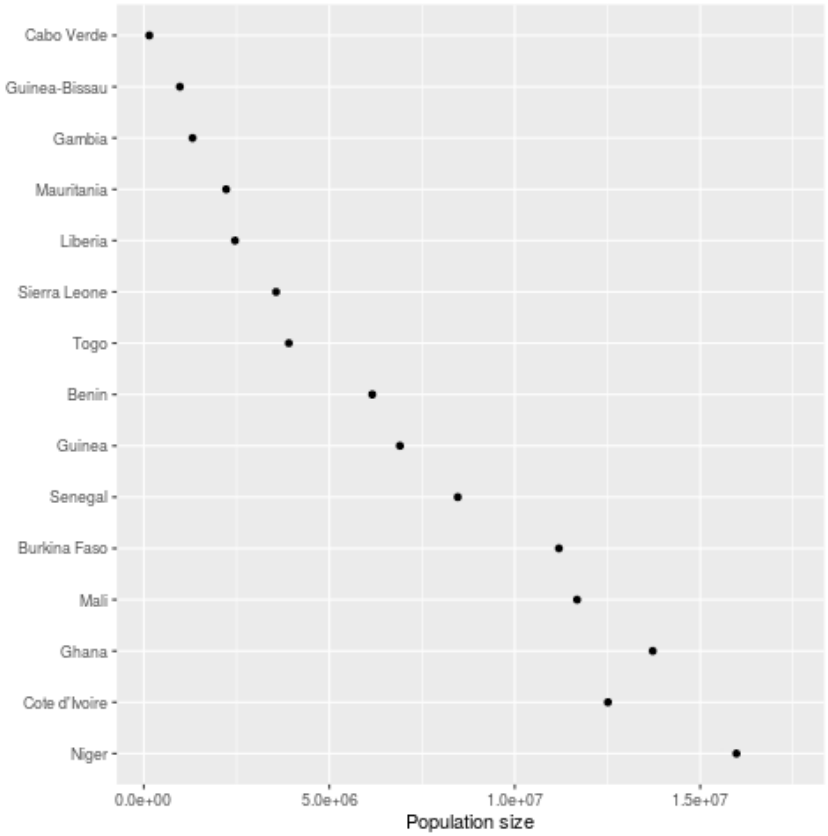
Static?

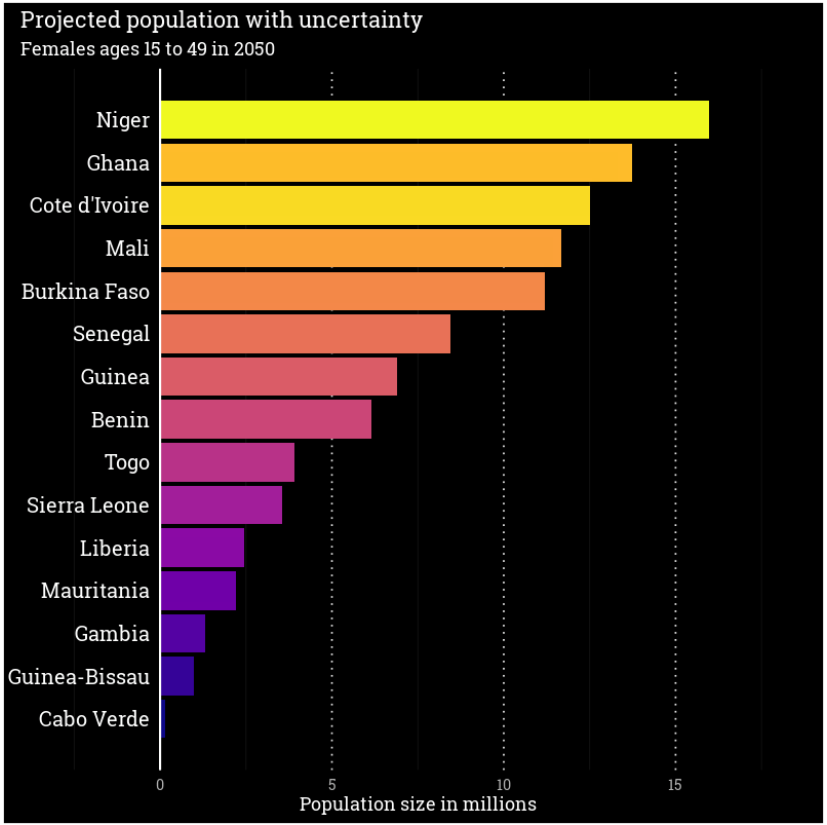


Schöley et al. (2017). Github.

Iteration

Iteration as **local refinement**





Schöley et al. (2017). Github.

Iteration

Iteration as **global search**

Define **design domain, goals & constraints**

Explore the **design space**

Explore the **data**

Rostock retreat on Data Visualization (2017). Via Twitter.

Iteration

Iteration as **global search**

Define **design domain, goals & constraints**

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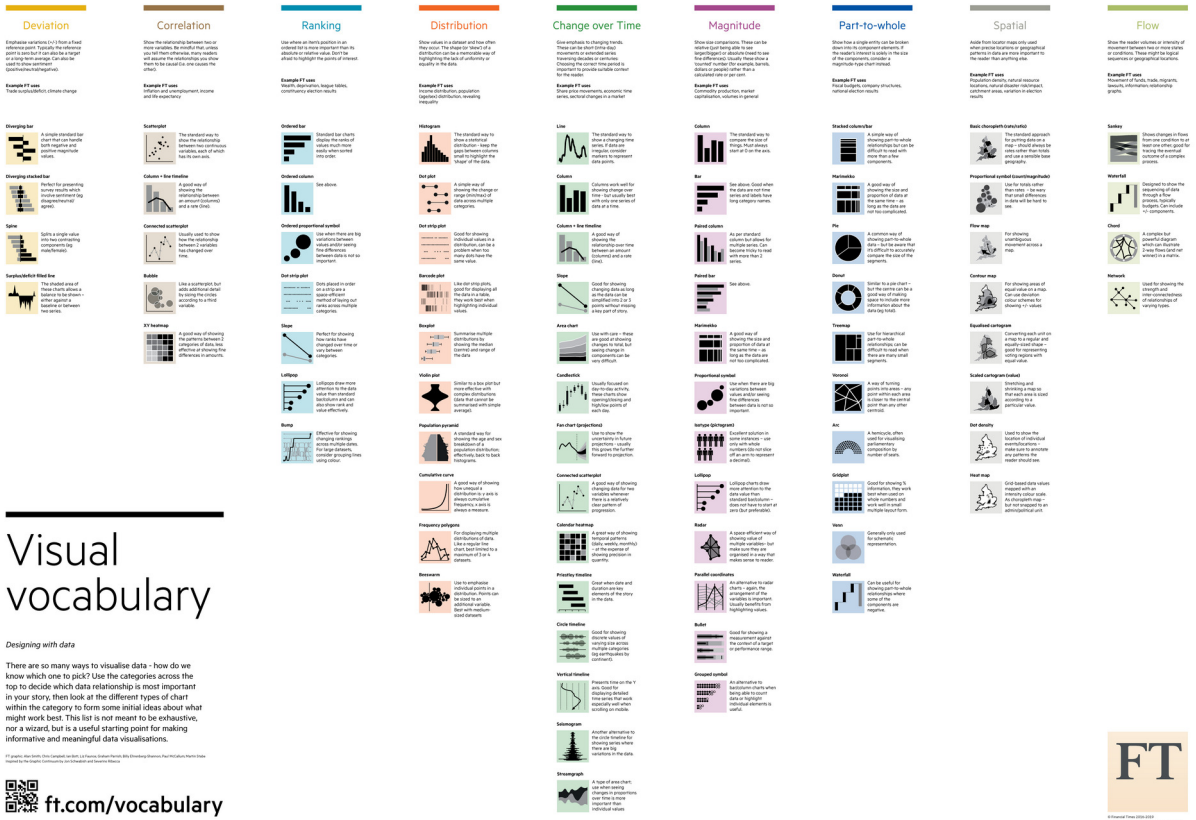

Financial Times Visual Journalism Team (2020). Visual vocabulary.

Iteration

Iteration as **global search**

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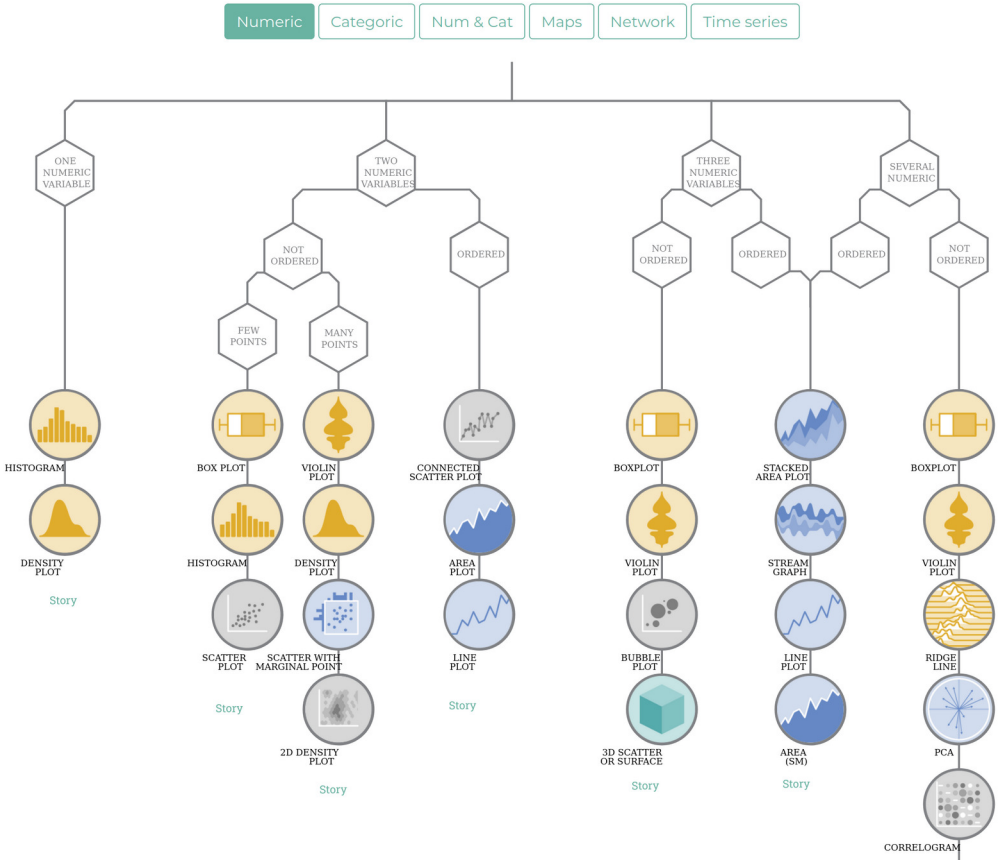


Holtz & Healy (2018). From Data to Viz.

Iteration

Iteration as **global search**

Define **design domain, goals & constraints**

Explore the **design space**

Explore the **data**

Wickham et al. (2024). ggplot2.tidyverse.org.

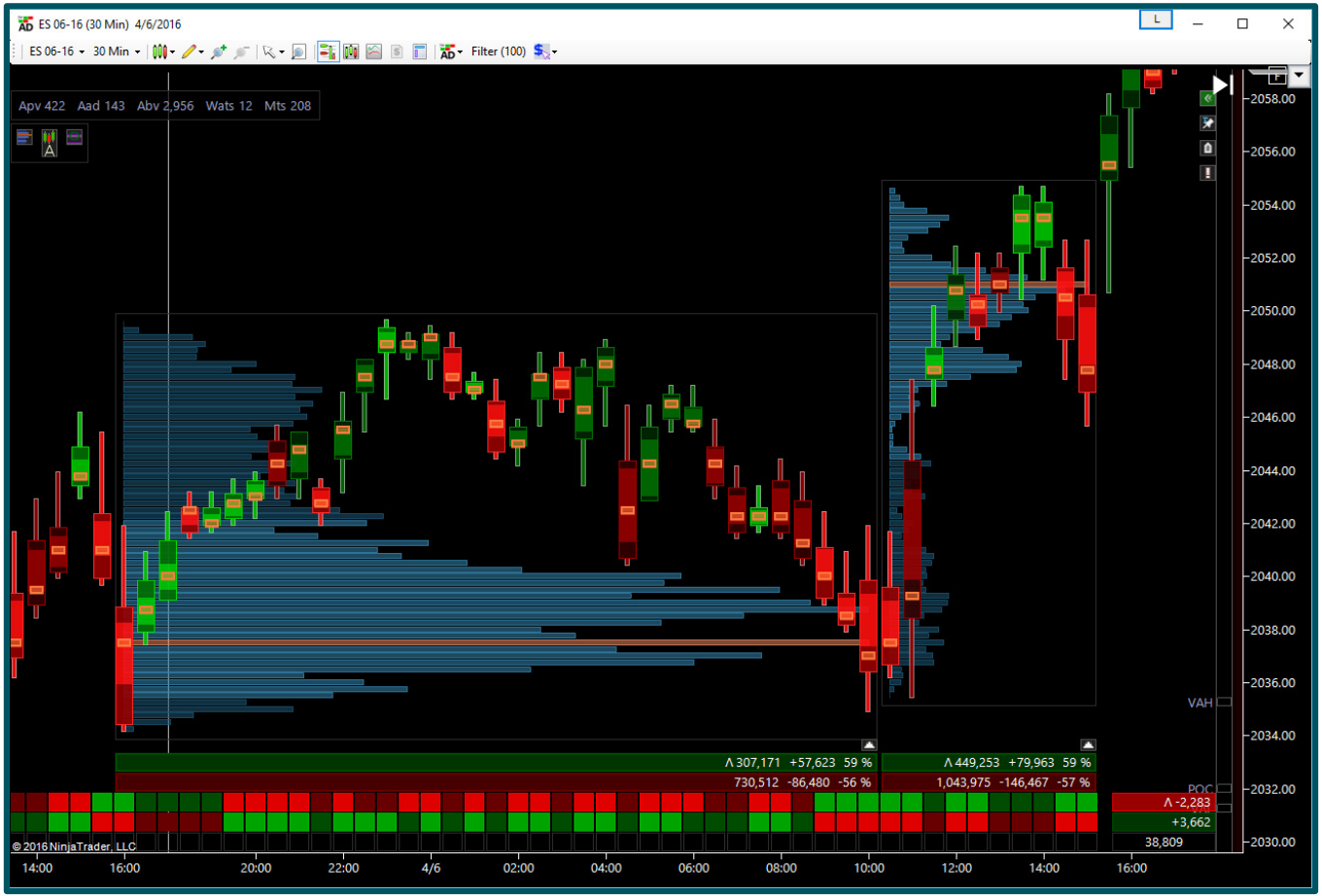
Schöley (2018). Tidy R Lecture Notes. Link.

What is a design process?

Iteration until converging on a predefined goal

Design domains, constraints & goals

Trader terminal

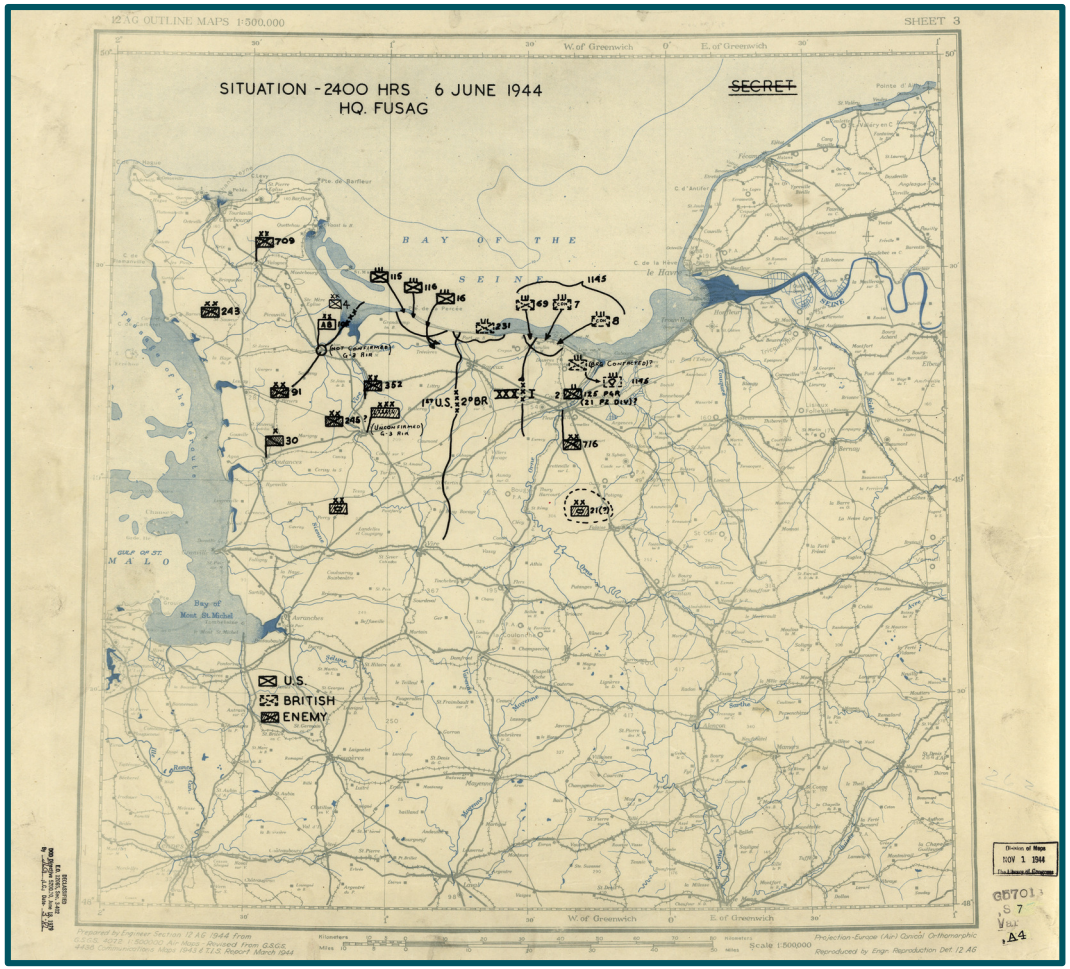


Auction Dashboard™ composite volume profile view.

Design domains, constraints & goals

Situation room

Official U.S. 12th army position map at 2400 hours on D-Day. Wikimedia.



Design domains, constraints & goals

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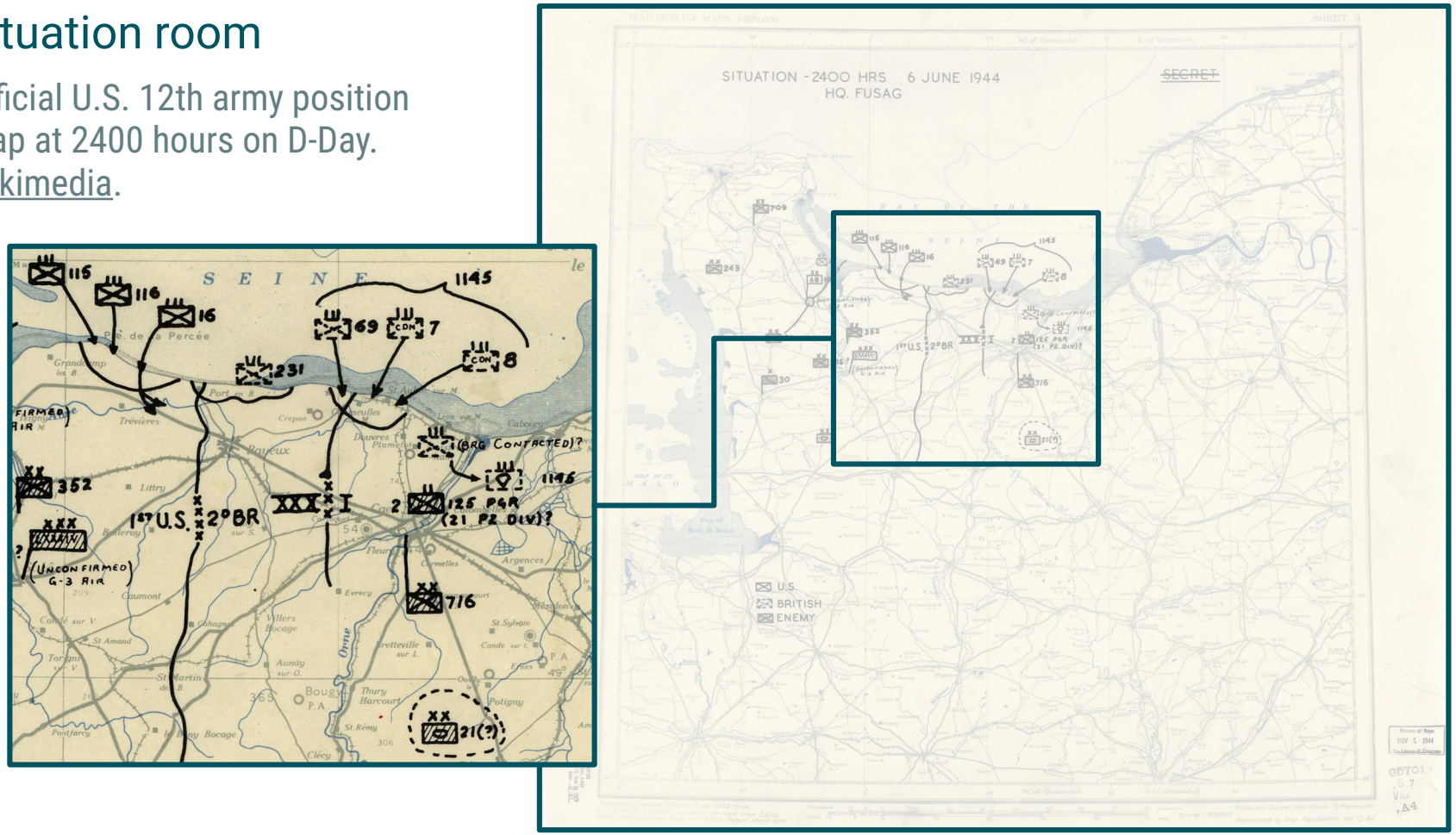
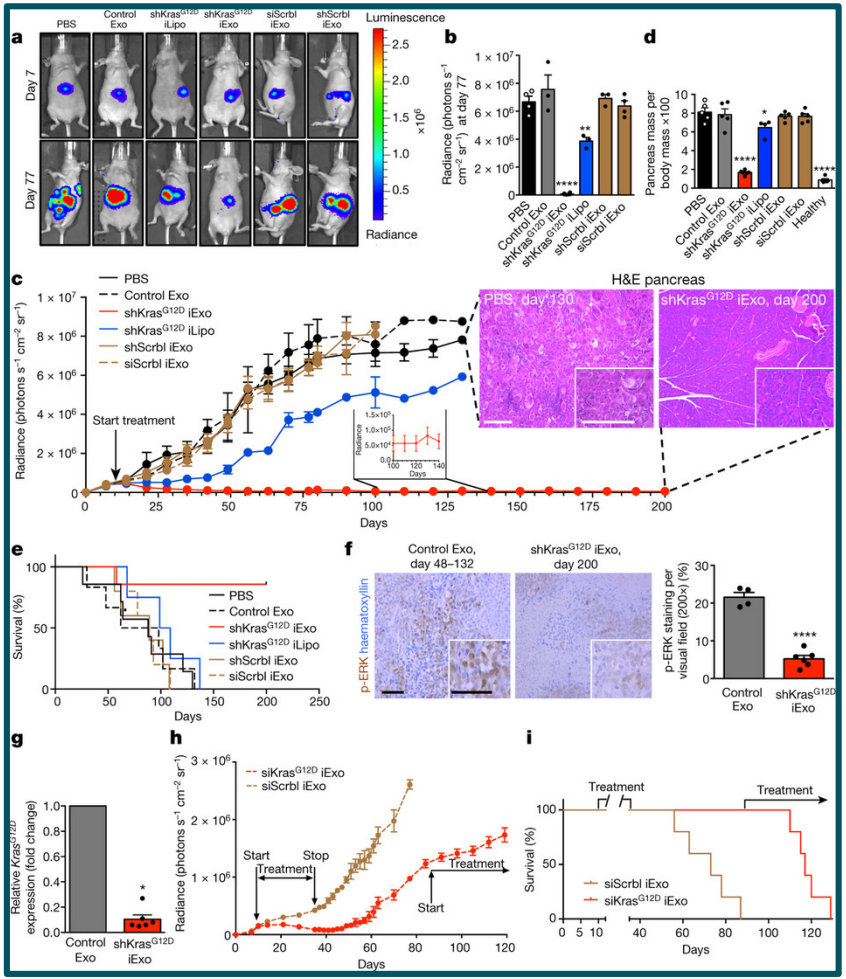


Design domains, constraints & goals

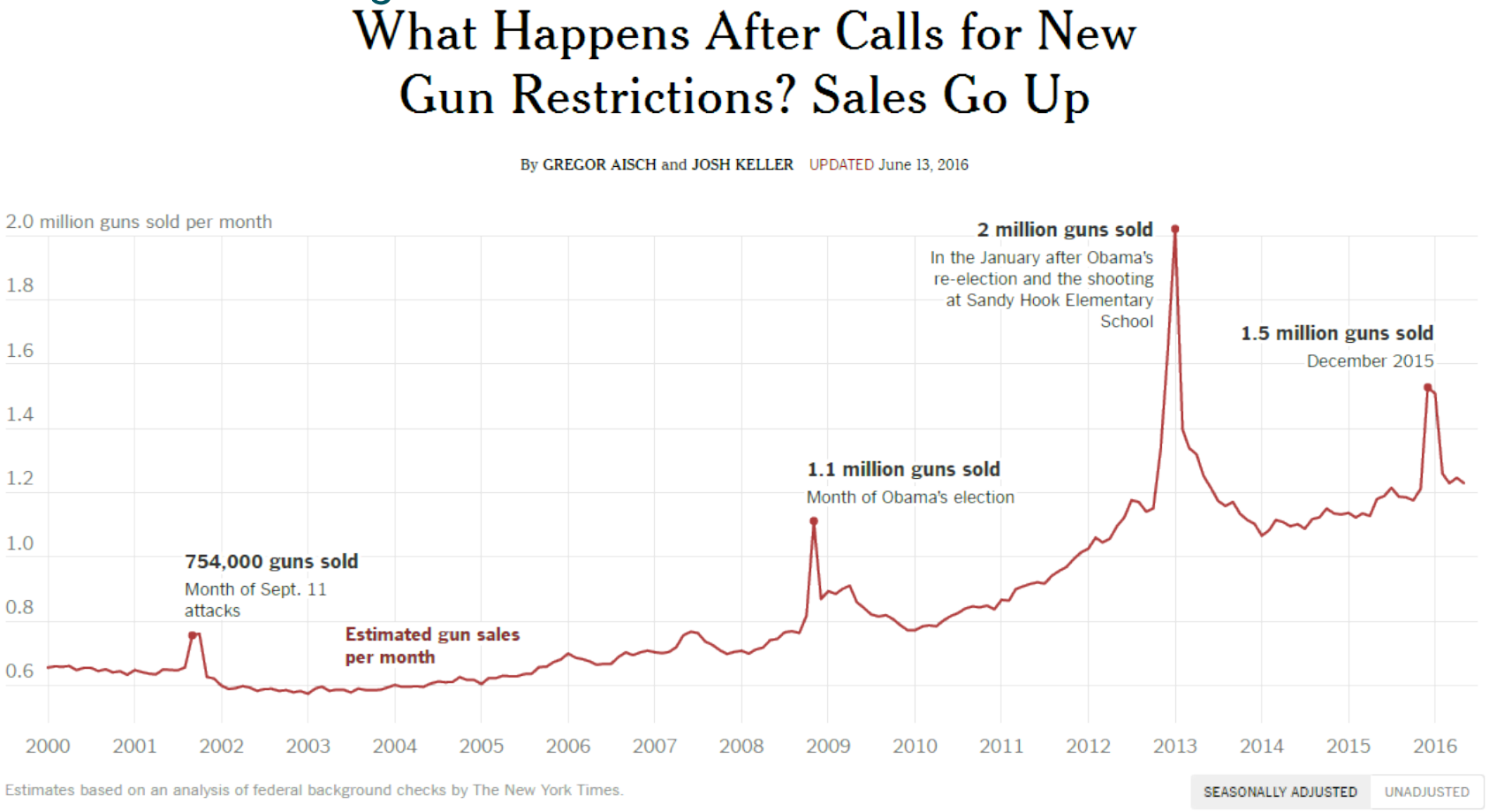
Situation room

Kamerkar et al. (2017). Exosomes facilitate therapeutic targeting of oncogenic KRAS in pancreatic cancer. Nature.



Design domains, constraints & goals

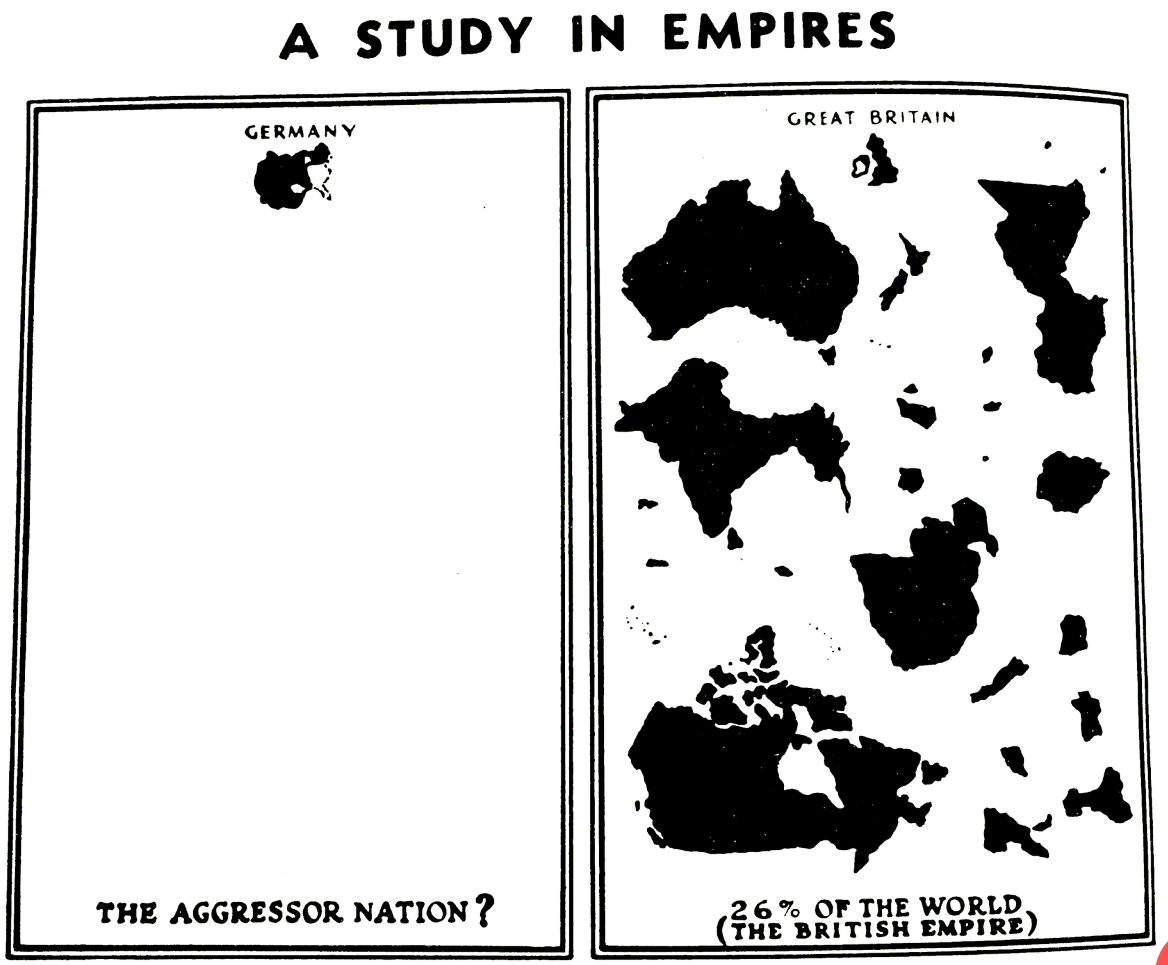
New York Times Figure 1 Gregor Aisch and Josh Keller (2016). NYT.



Design domains, constraints & goals

War propaganda

Monmonier (1996). How to Lie with Maps. Reprinted from German Library of Information (1940). A study in empires. Facts in Review 2 (5).



Explicit design goals

Design domains, constraints & goals

General goals

Rost (2017). Why do we visualize data?
INCH conference presentation.

Design domains, constraints & goals

Specific goals

Schöley & Willekens (2017). Visualizing compositional data on the Lexis surface. 10.4054/DemRes.2017.36.21.

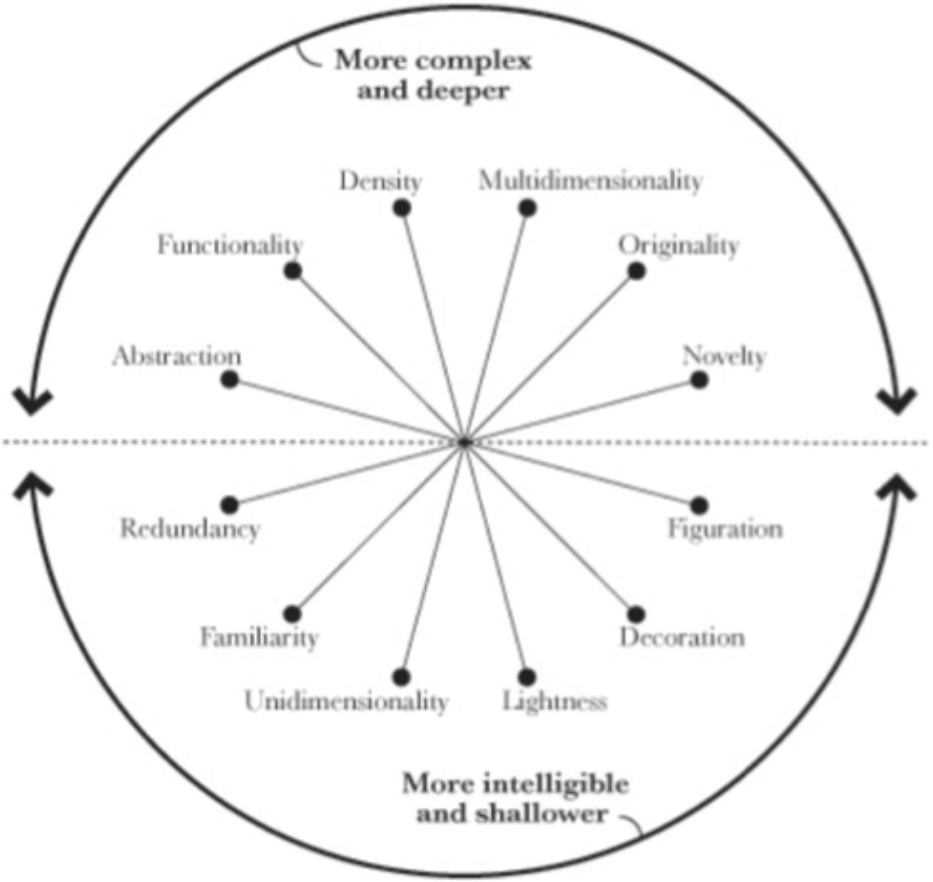
Table 1: Evaluation of different visualization techniques for compositional data on the Lexis surface

	Ternary-balance scheme	Qualitative-sequential scheme	Agewise-area plot	Small multiples
Completeness	yes	no	yes	yes
Continuity	yes	yes	no	yes
Category limit	3	≈ 5–6	≈ 8	unlimited
Pattern perception	good	good	limited	good
Table lookup	limited	limited	limited	limited
Colour-accessible	no	no	yes	yes
Footprint	small	small	small	large

Design domains, constraints & goals

Goal trade-offs

Cairo, A. (2012). The Functional Art.
An introduction to information graphics and visualization.
Link.



Design goal effective task abstraction

Cleveland, W. S., & McGill, R. (1984). Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods. Journal of the American Statistical Association, 79(387), 531.

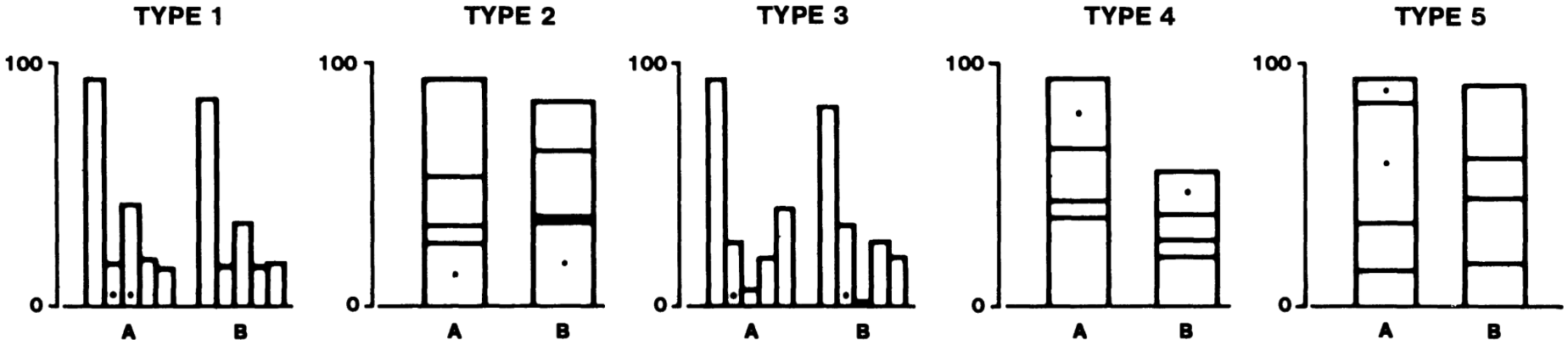


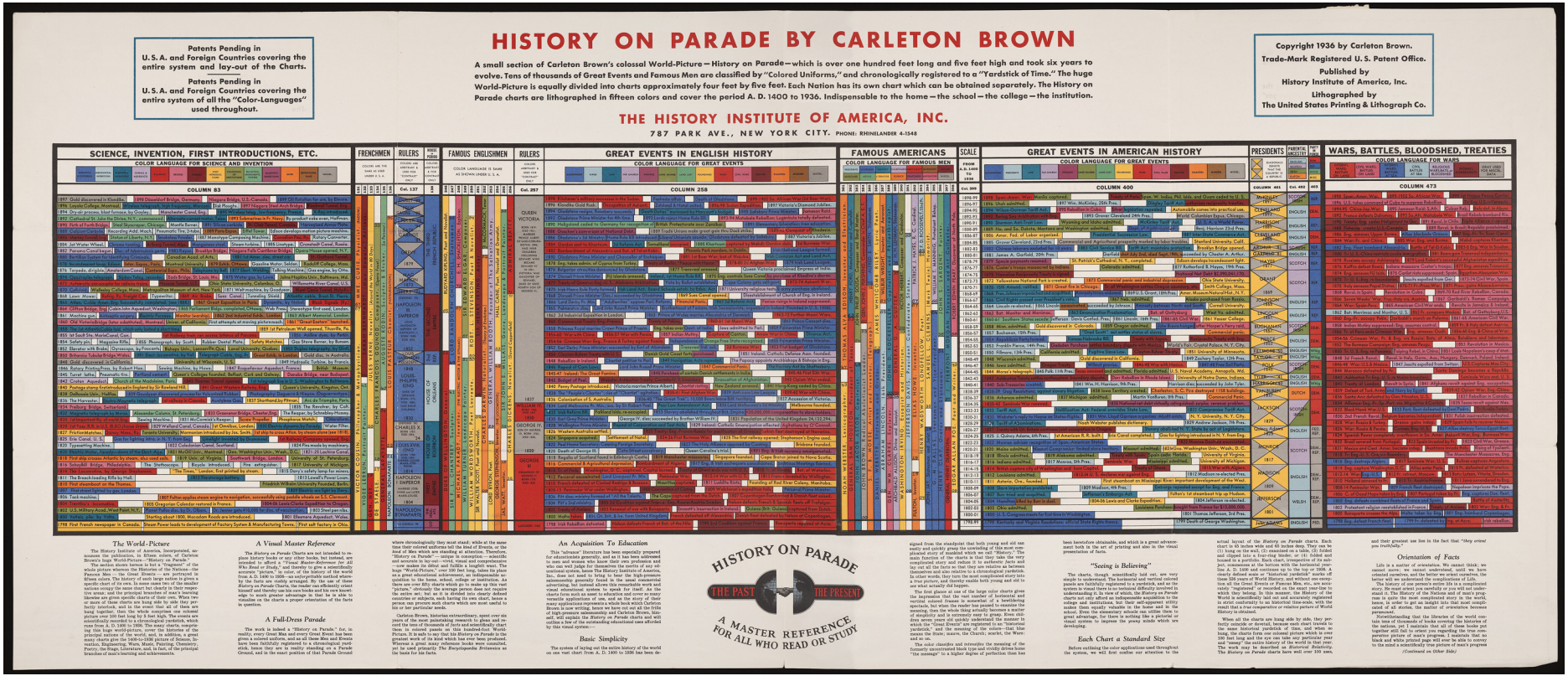
Figure 4. Graphs from position–length experiment.

Design goal Attention and engagement

Markus Wende (2016). Wimmelbild “Recht auf Stadt” [cutout]. Link.

Design goal Attention and engagement

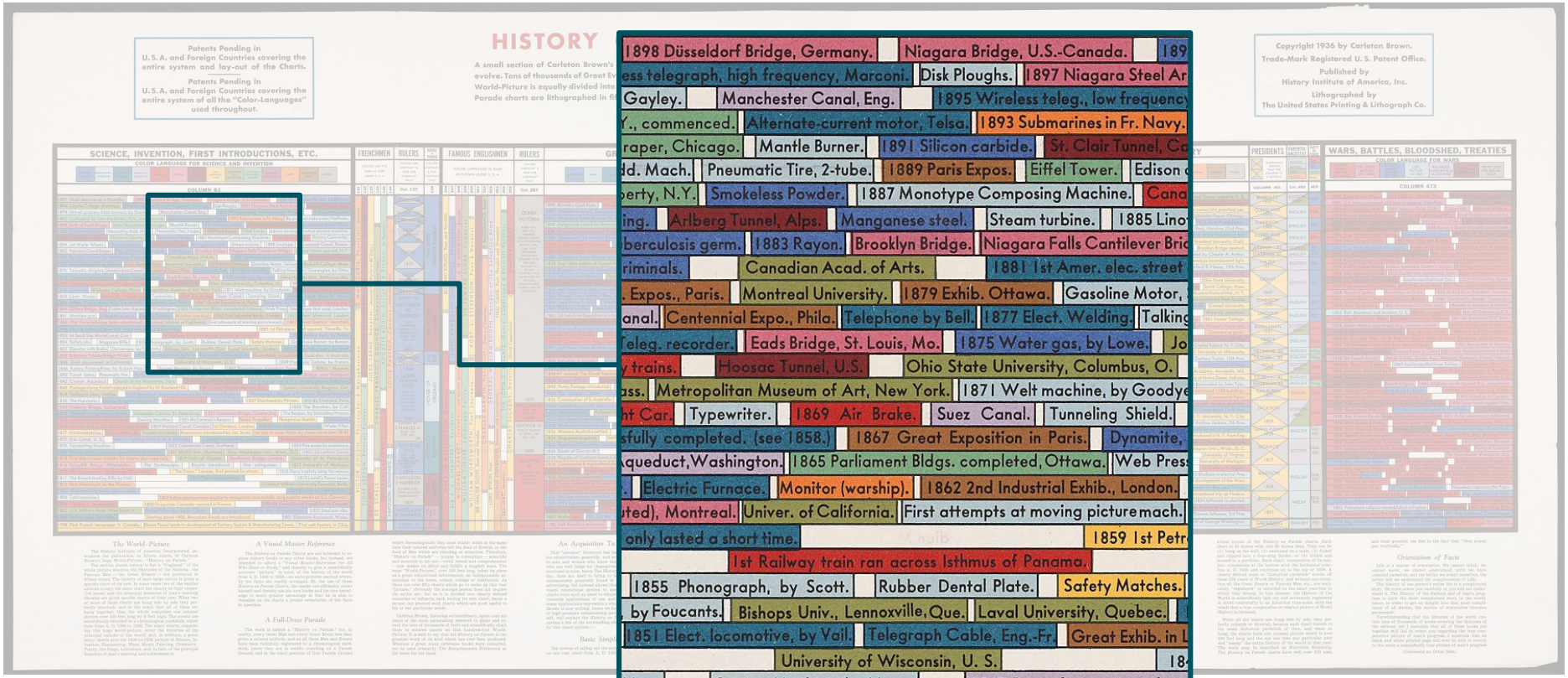
Macro view



Carleton Brown (1936). History on parade by Carleton Brown. History Institute of America, Inc.

Design goal Attention and engagement

Micro view



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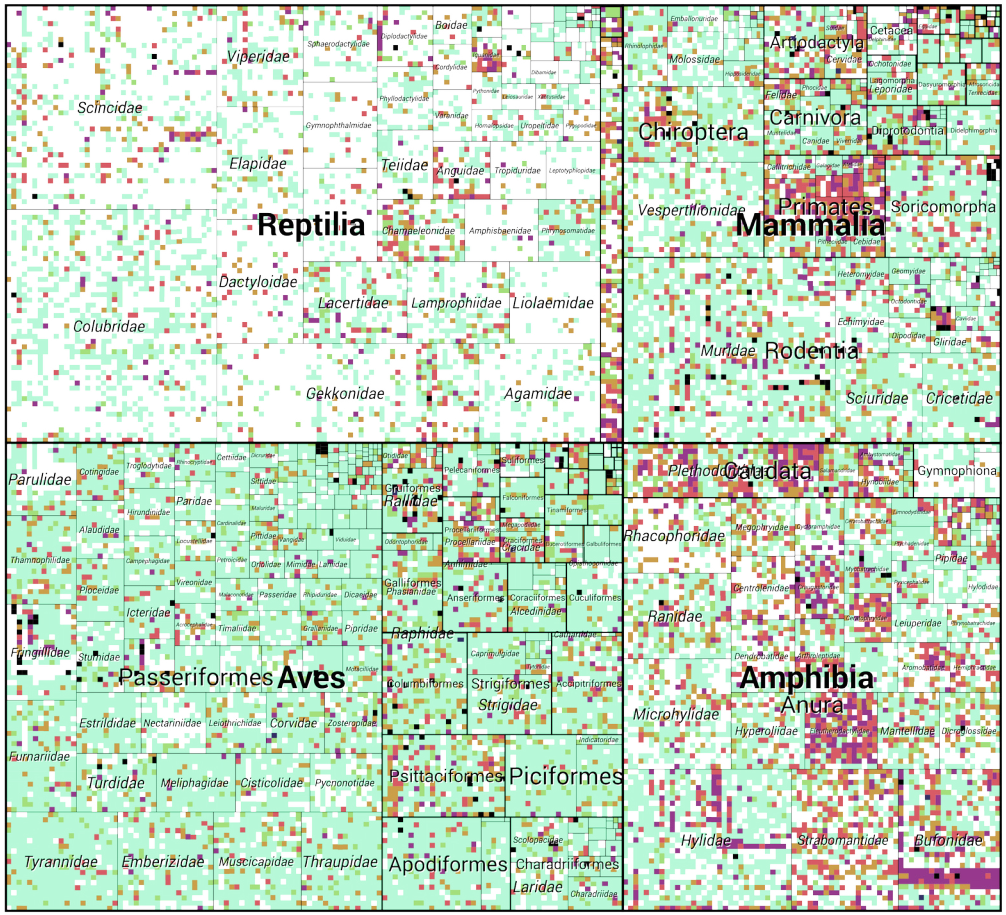


The State of Vertebrate Conservation

IUCN Red List conservation status for each species

IUCN Conservation Status

- Extinct
- Extinct in the Wild
- Critically Endangered
- Endangered
- Vulnerable
- Near Threatened
- Least Concern
- Unknown

Threatened

Taxonomic Rank

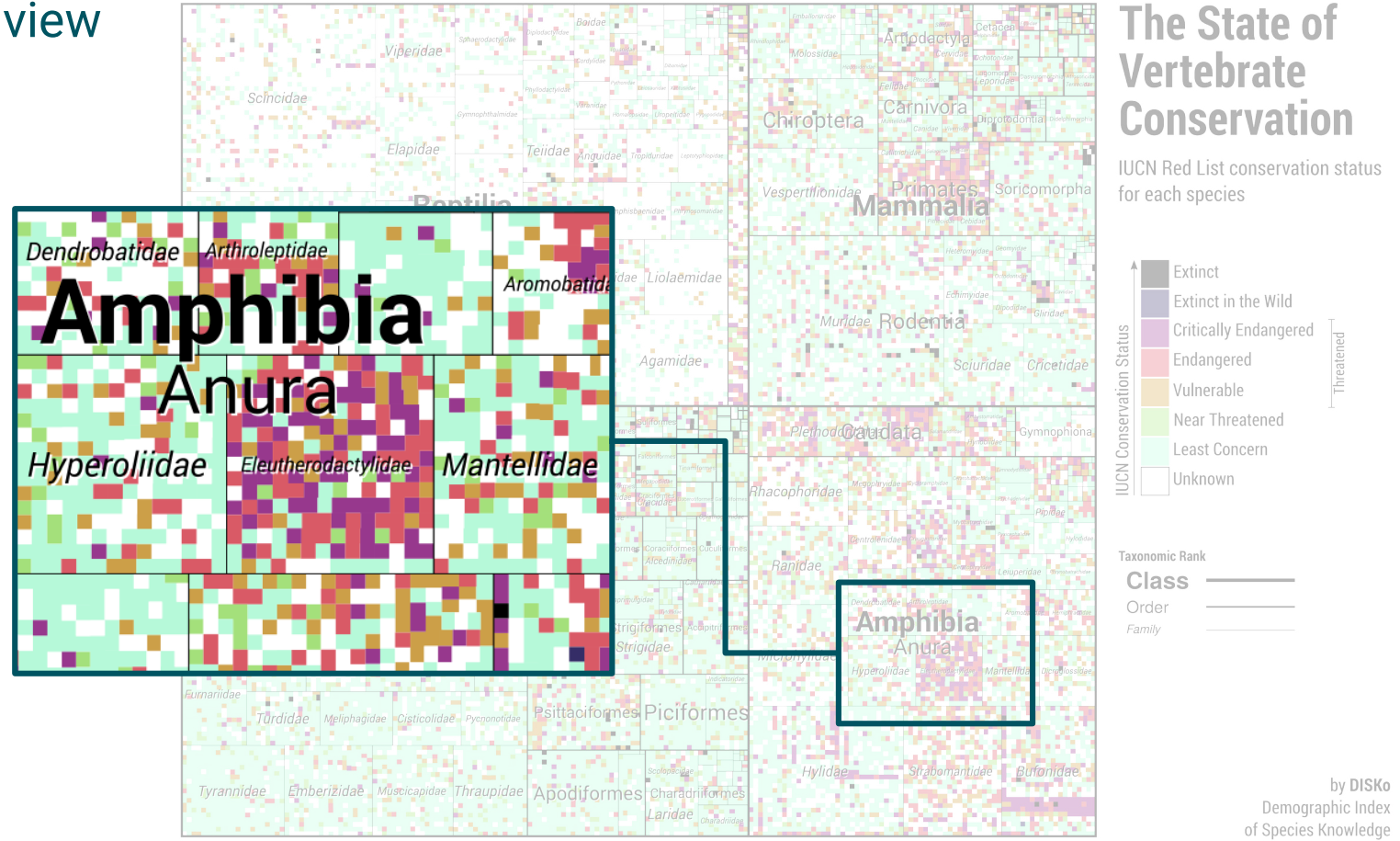
- Class
- Order
- *Family*

by **DISKo**
Demographic Index of Species Knowledge

Conde et al. (2019). Data gaps and opportunities for comparative and conservation biology. PNAS.

Design goal Attention and engagement

Micro view



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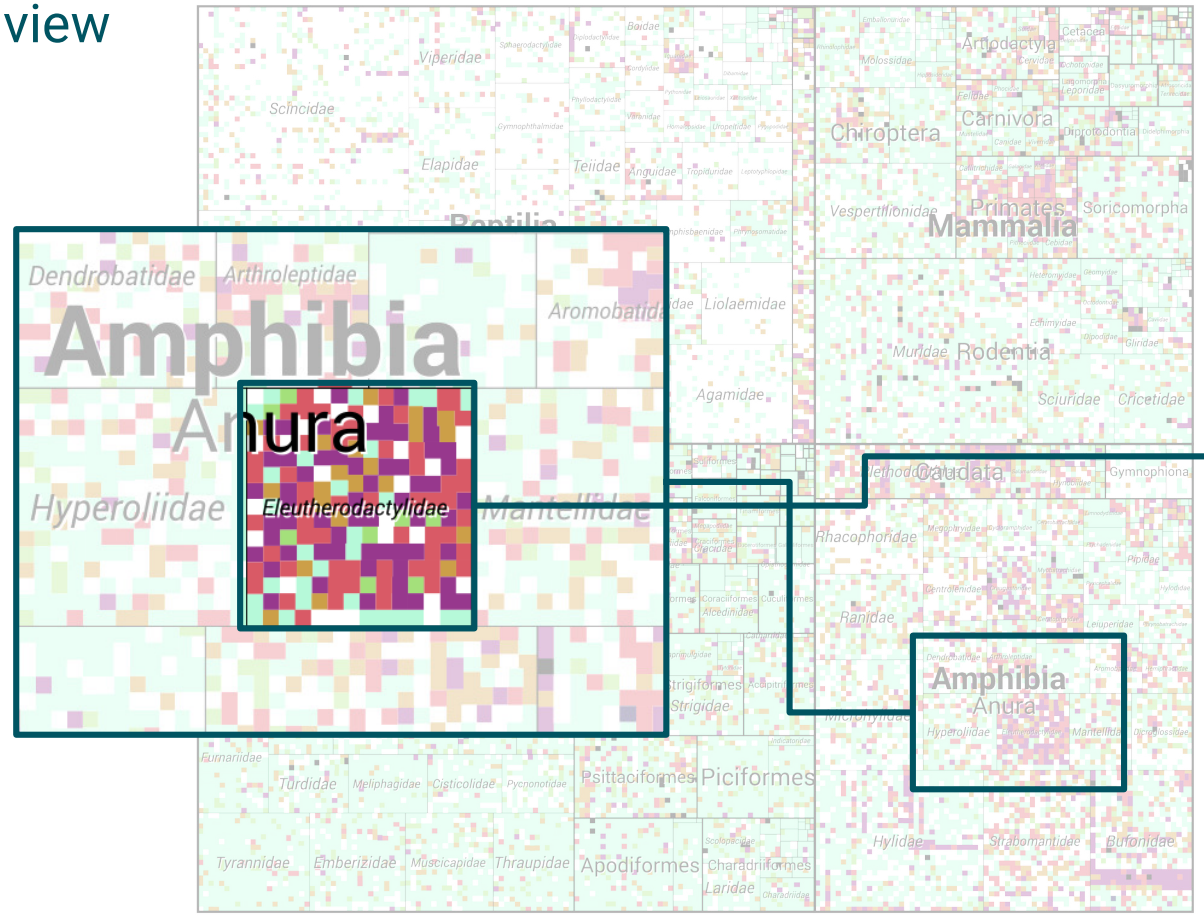
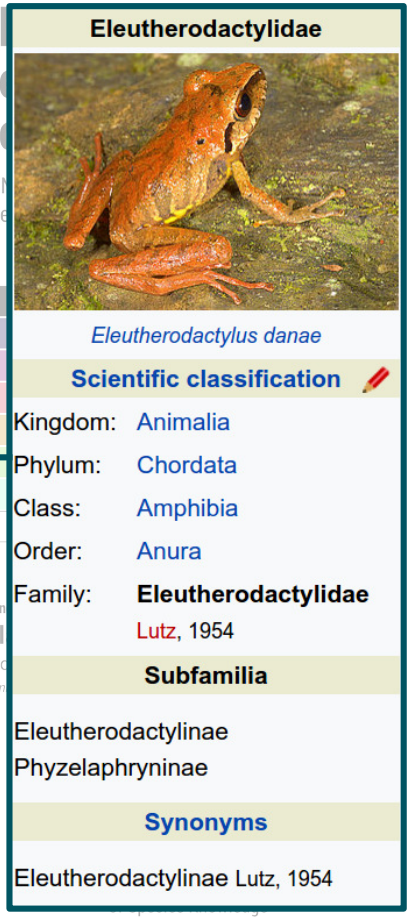
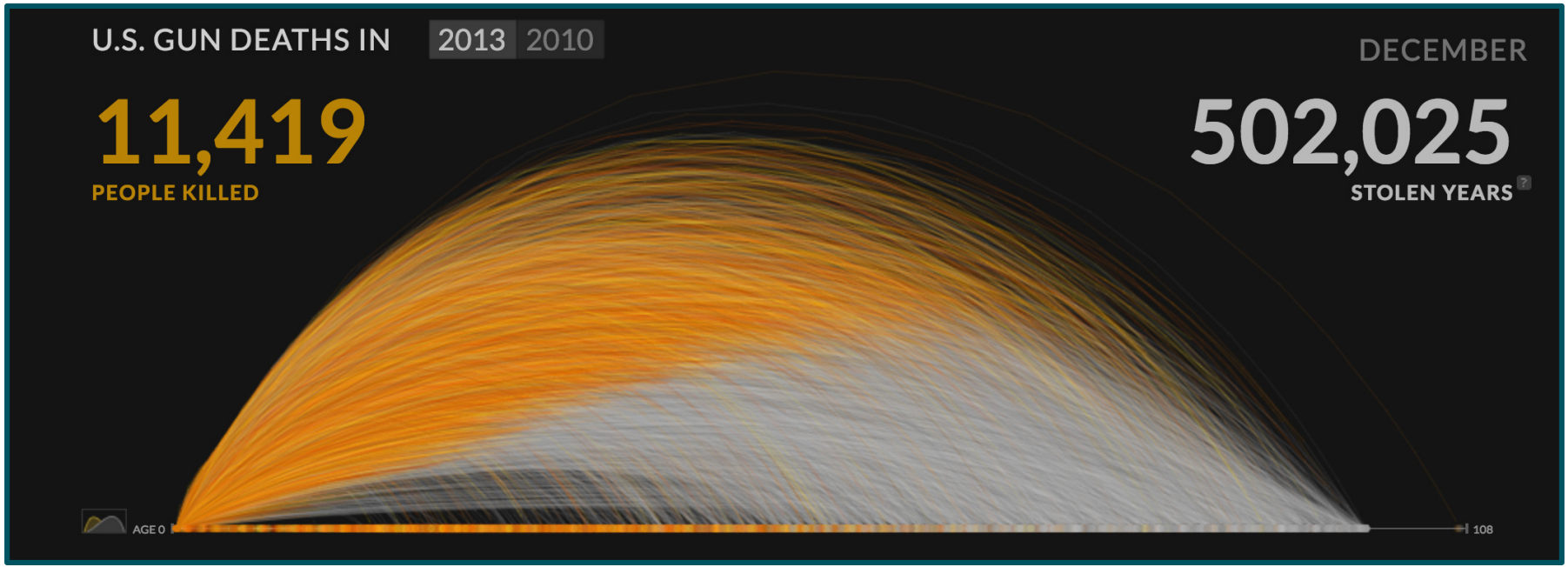




en.wikipedia.org/wiki/Eleutherodactylidae

Conde et al. (2019). Data gaps and opportunities for comparative and conservation biology. PNAS.

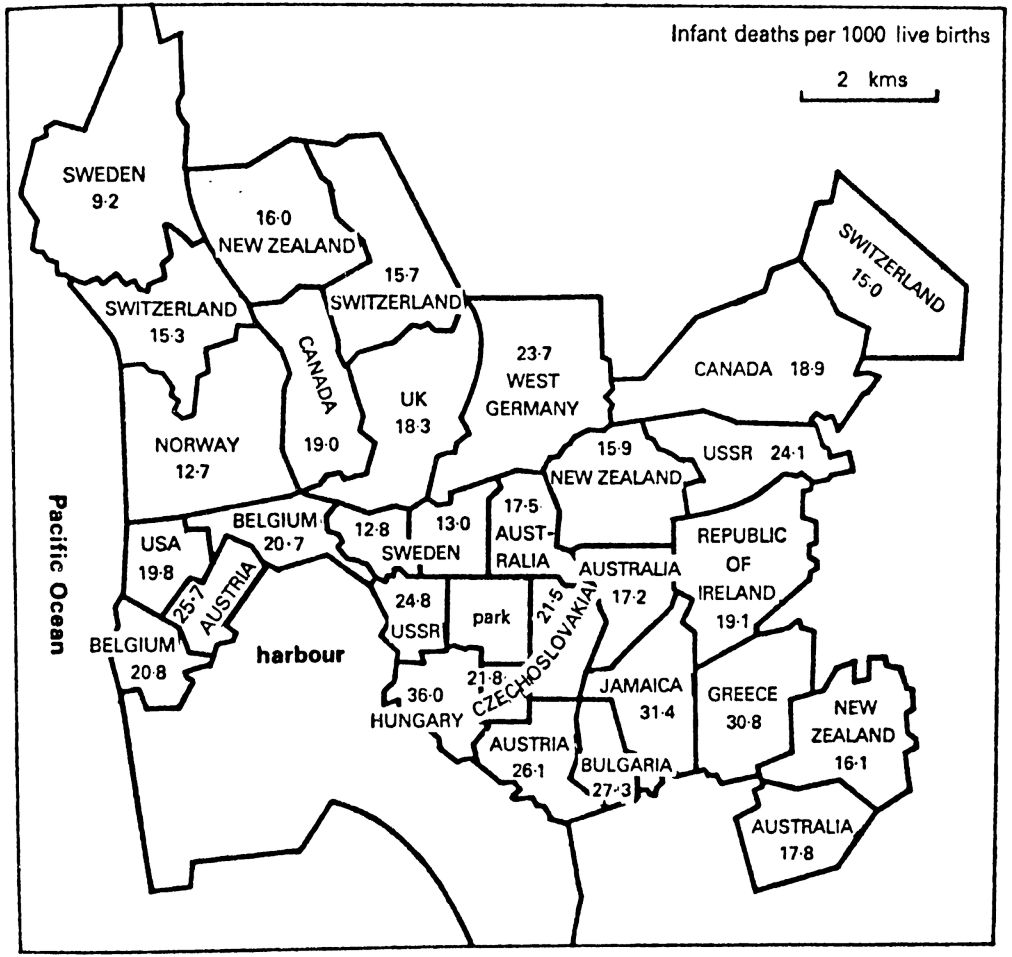
Design goal Influence



Periscopic (2013). guns.periscopic.com.

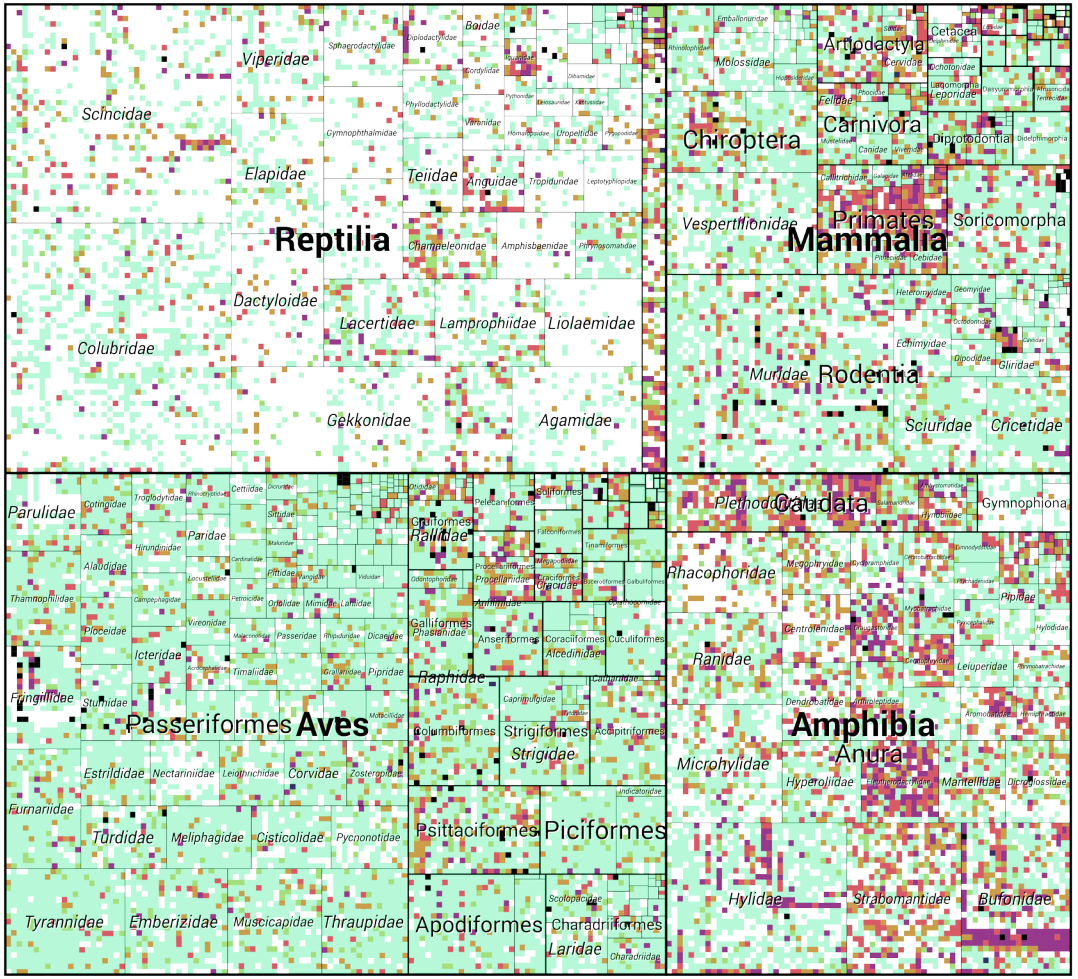
Design goal Influence

Infant mortality rates for parts of San Diego, California expressed in national rates of comparable nations. Via Monmonier (1996). How to lie with maps.



Competing design goals

Competing design goals Engagement & density versus effectiveness



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by **DISKo**
Demographic Index of Species Knowledge

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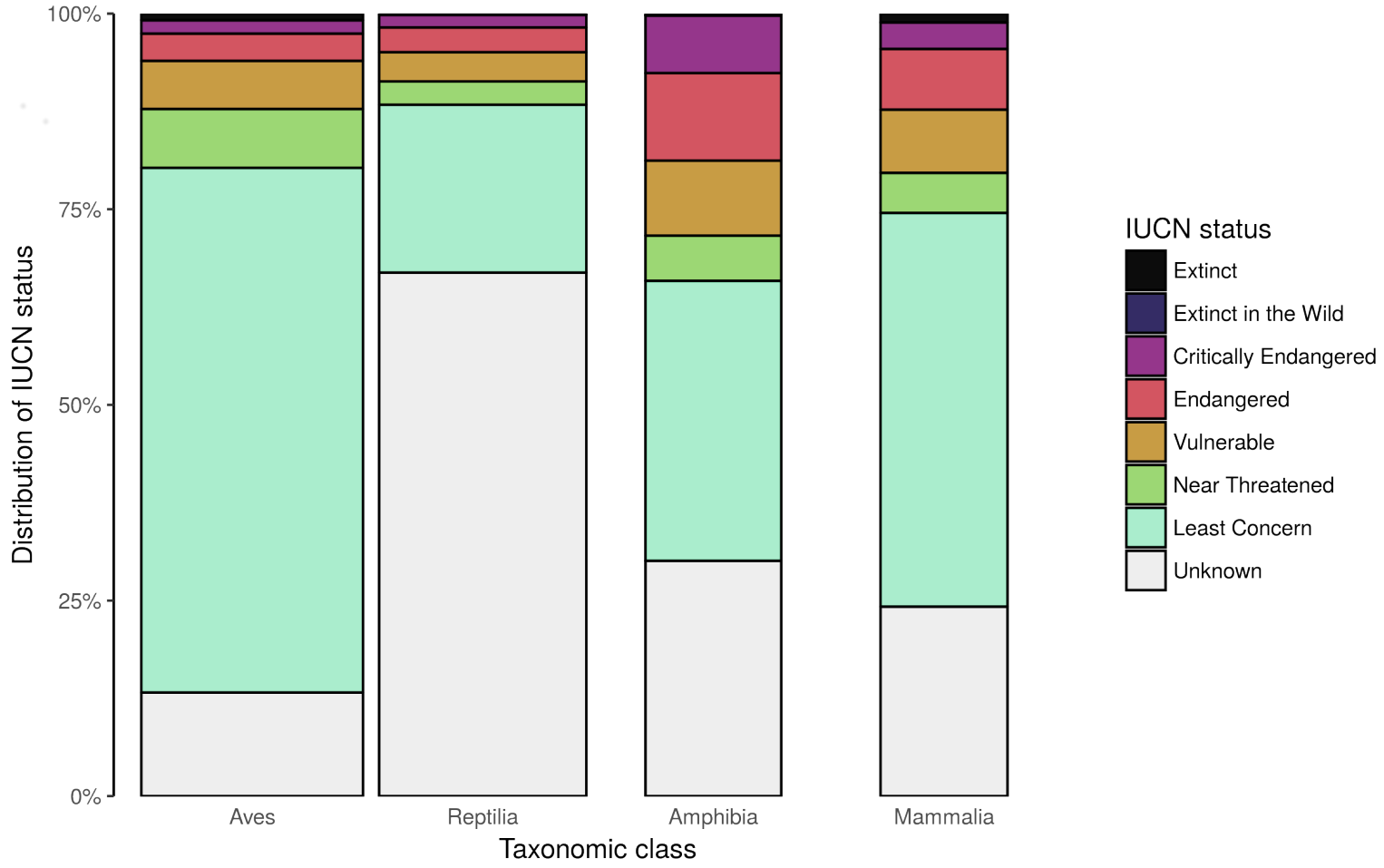
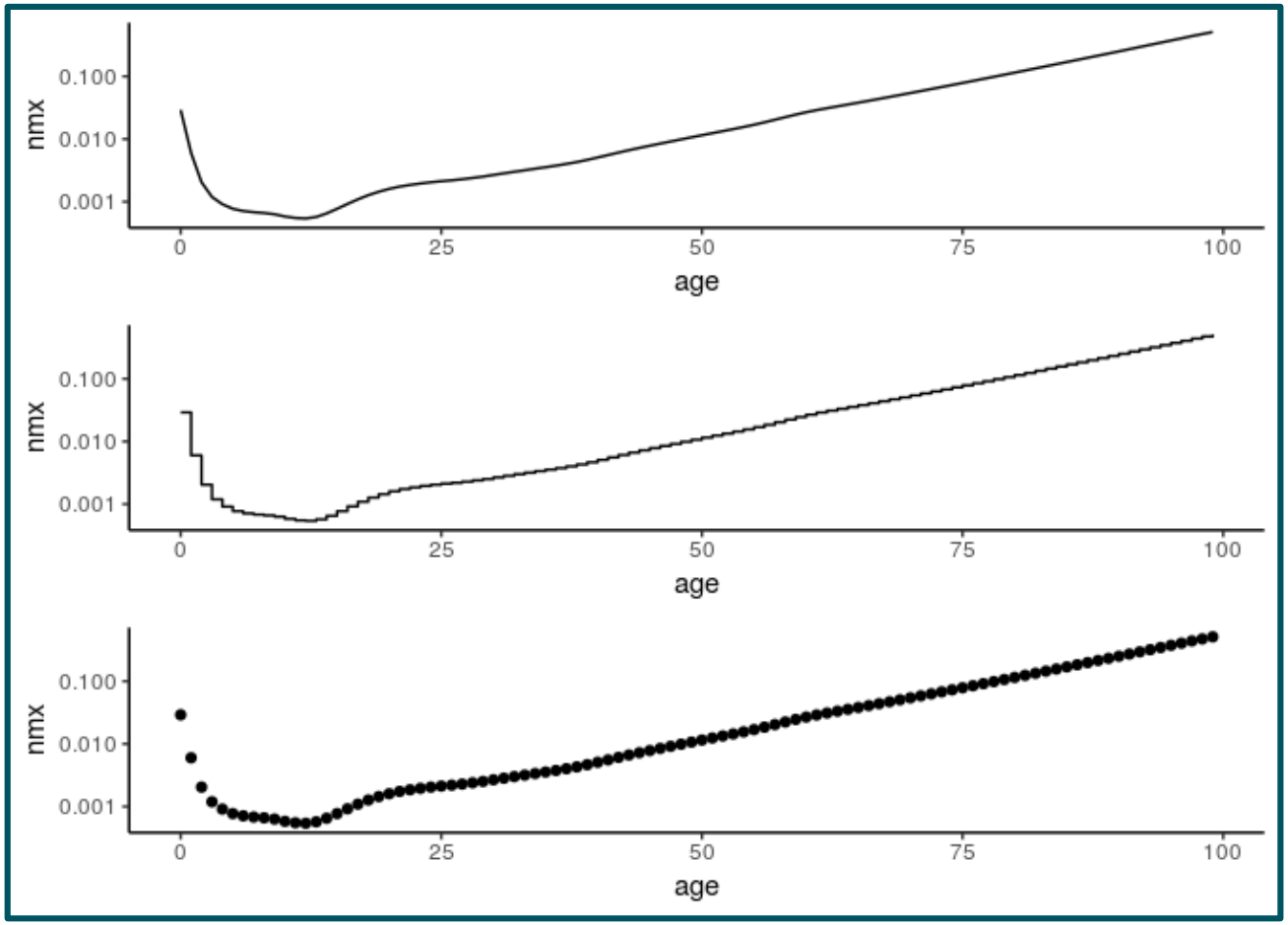


Competing design goals Precision vs. clarity



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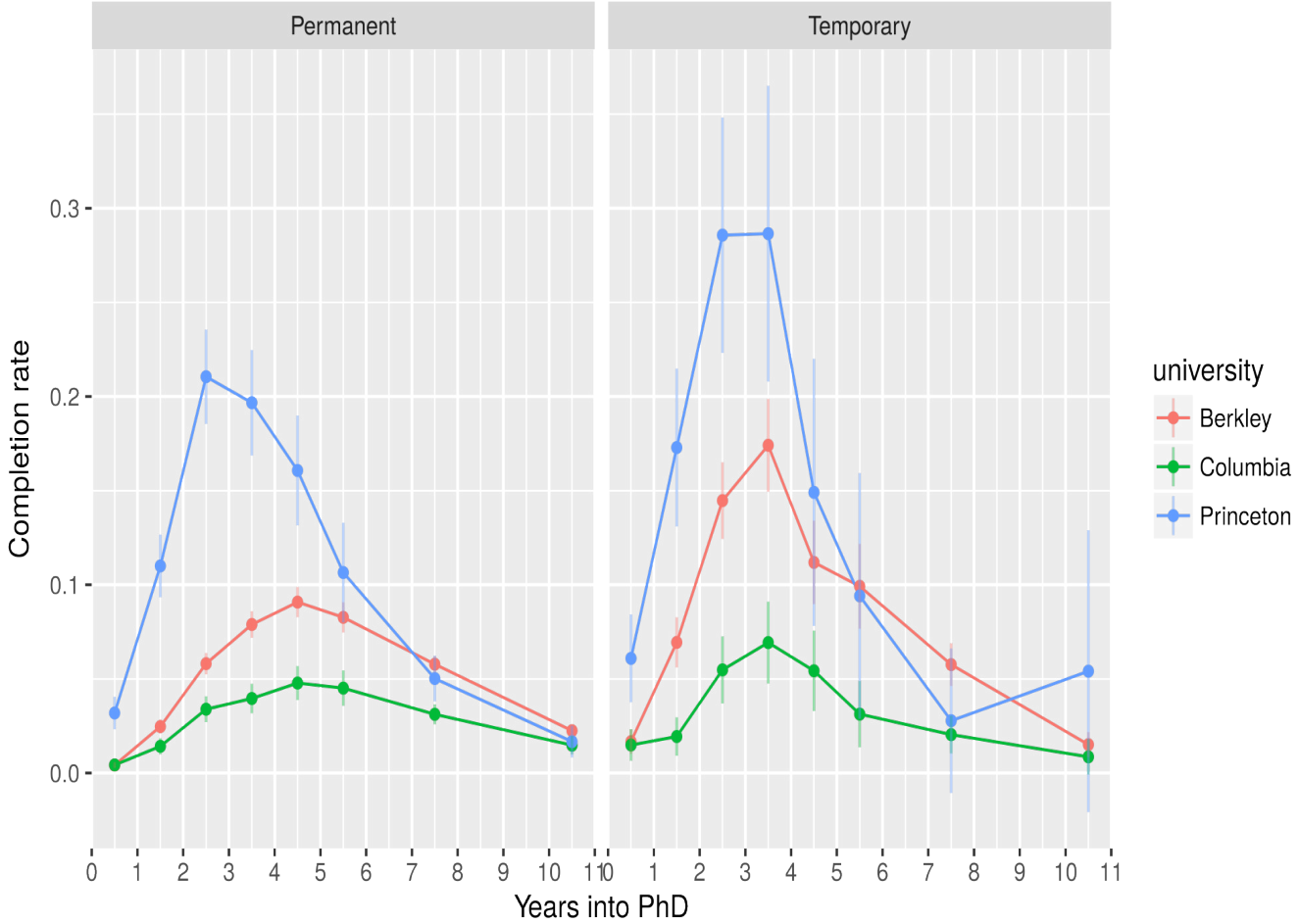

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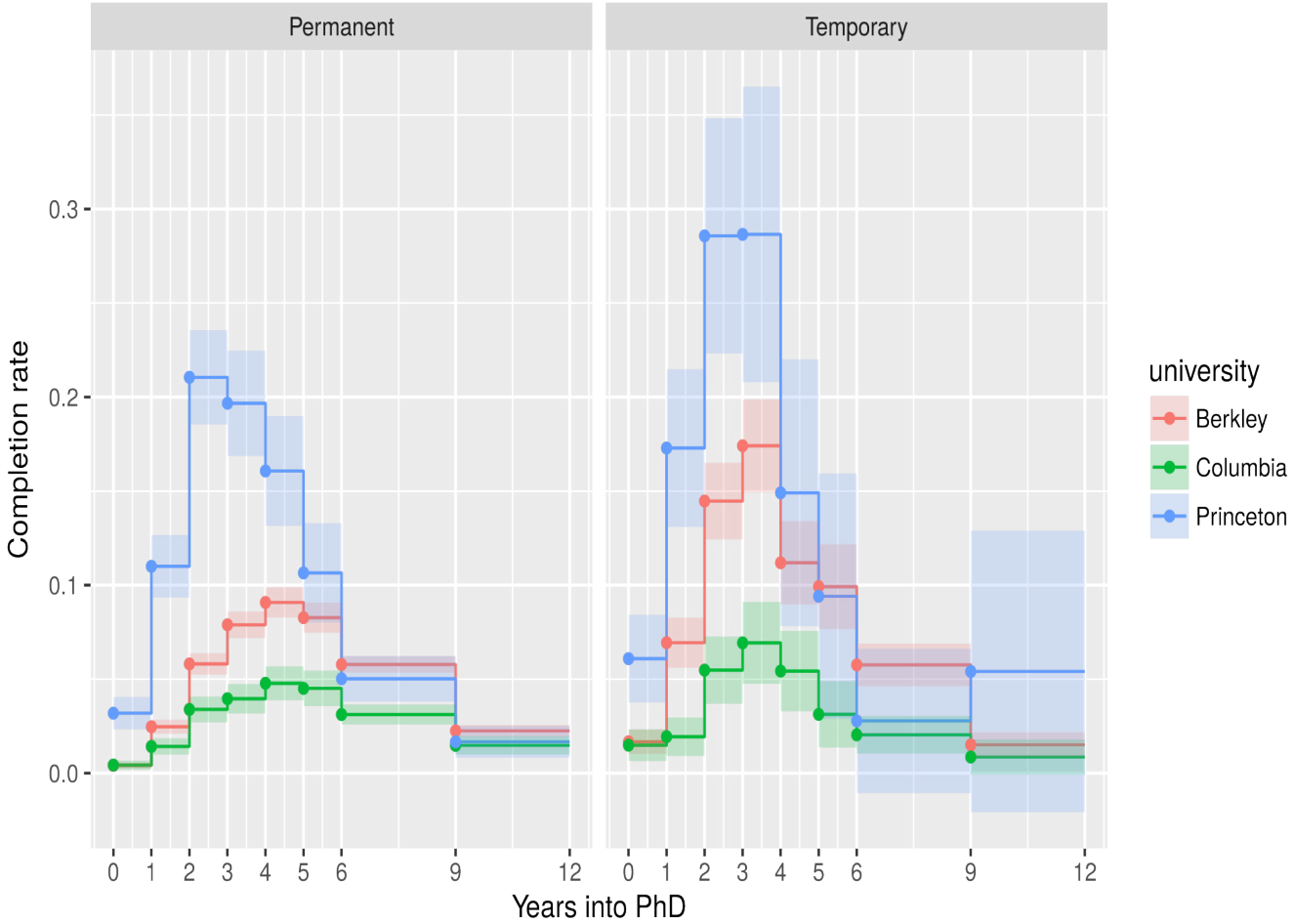

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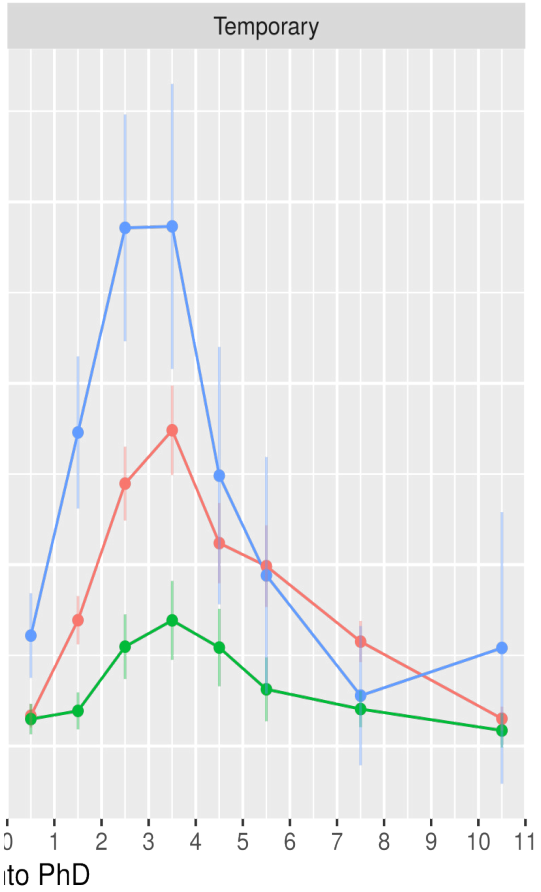

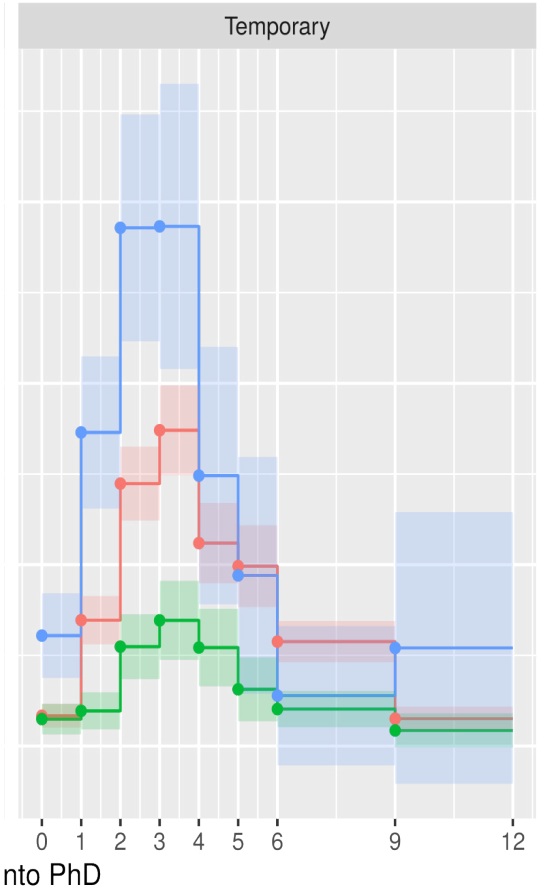

Competing design goals

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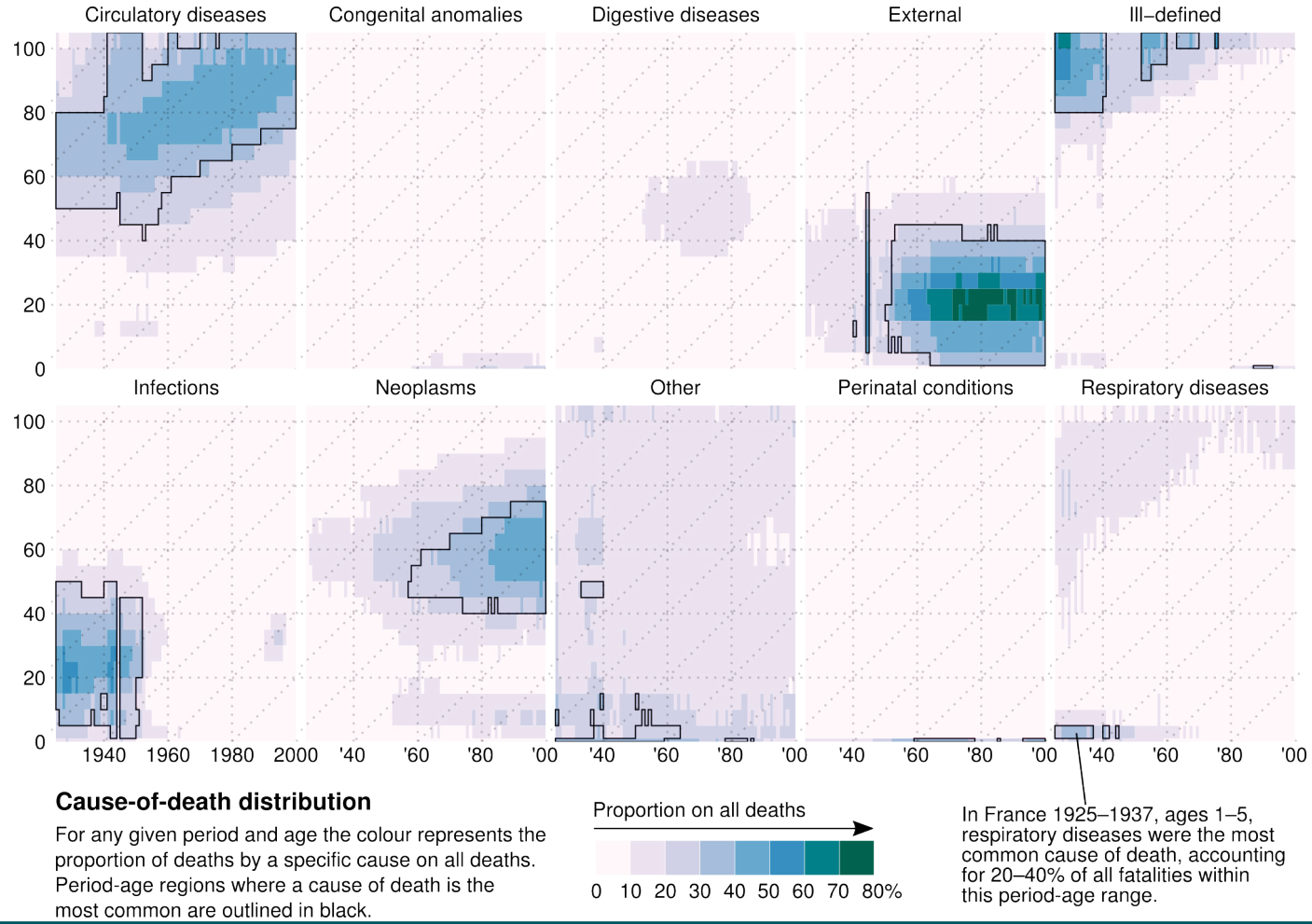

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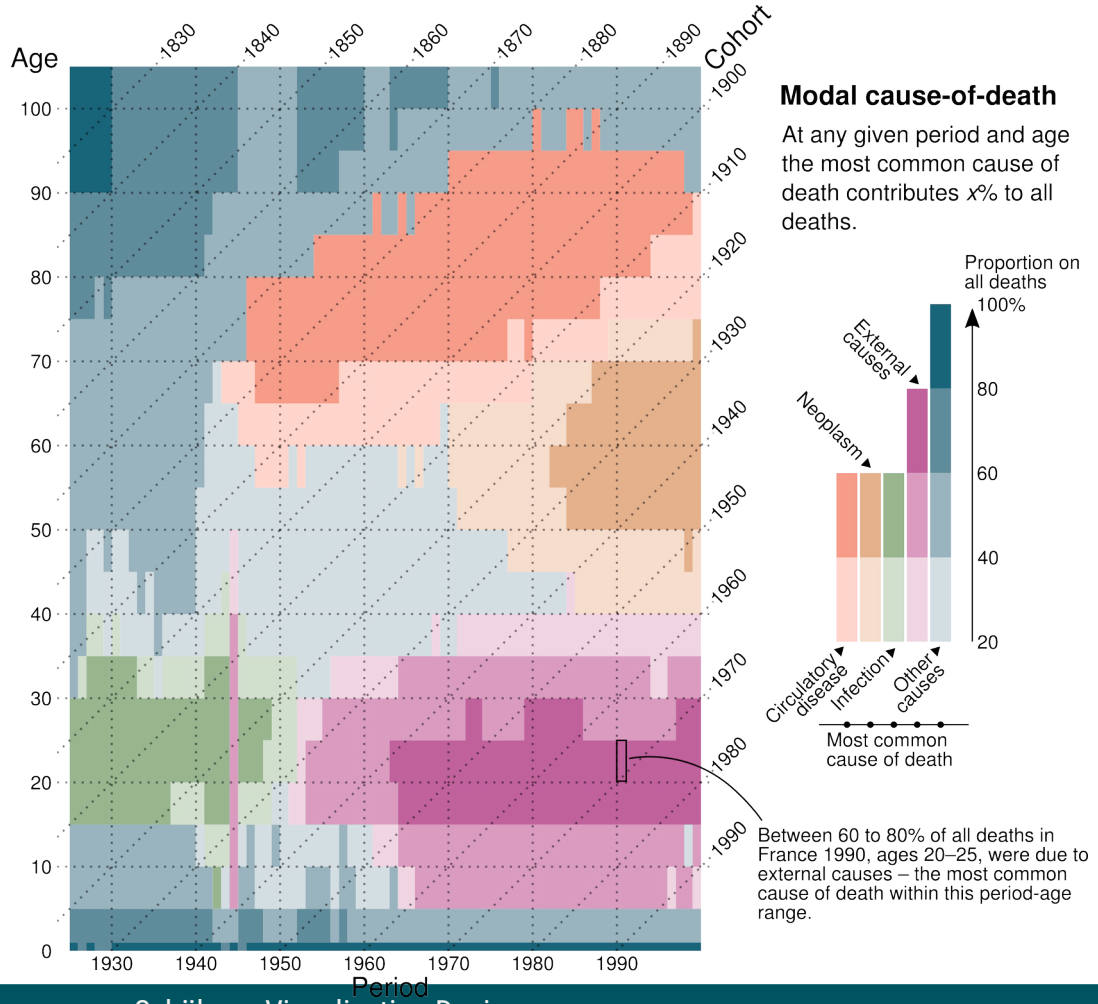

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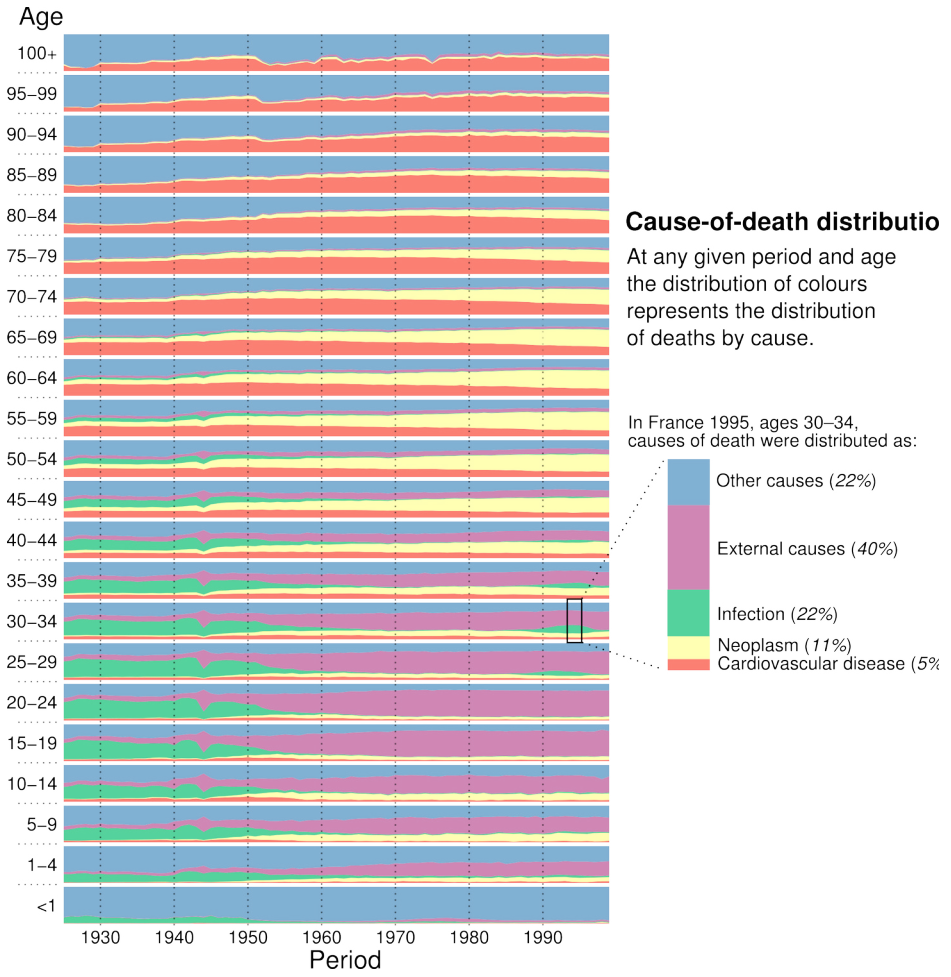

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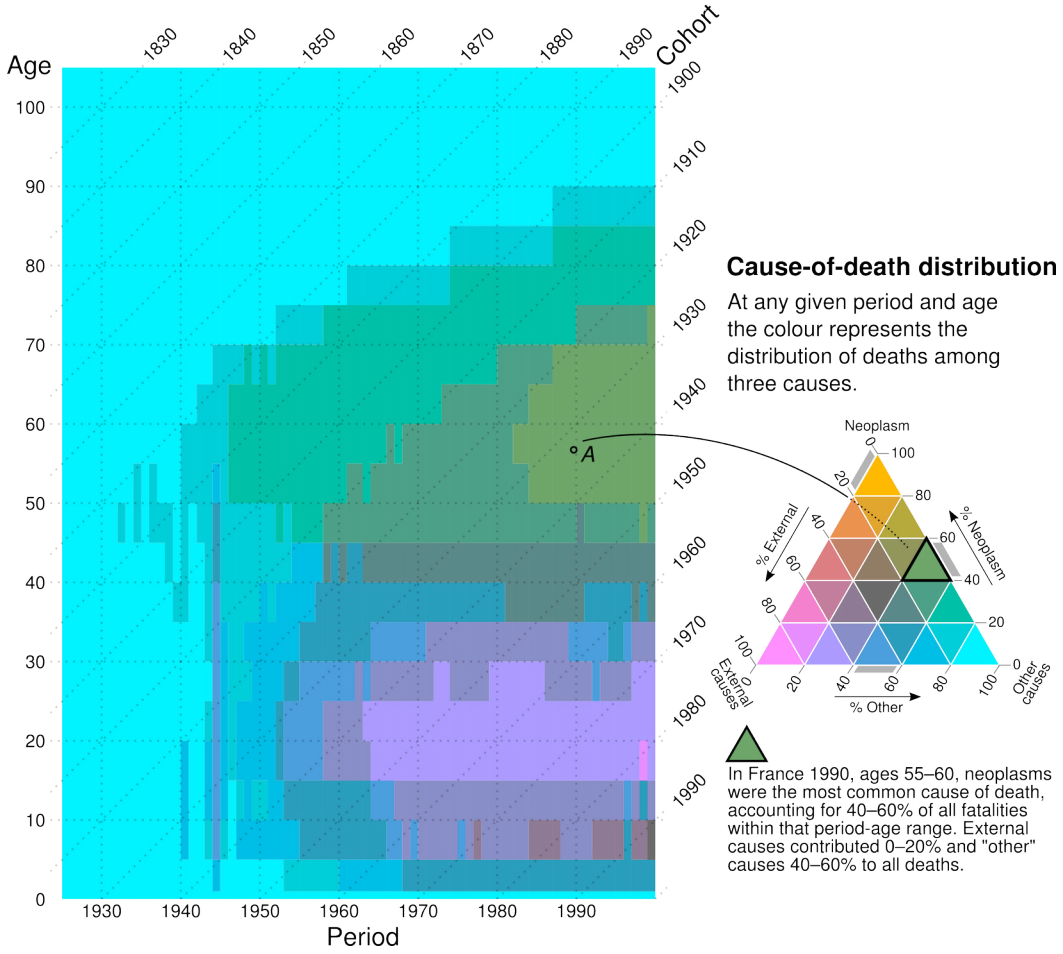

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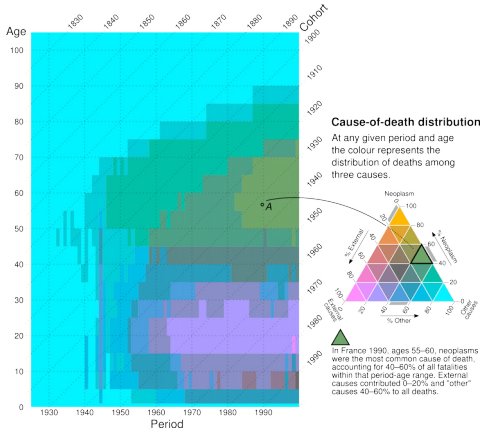
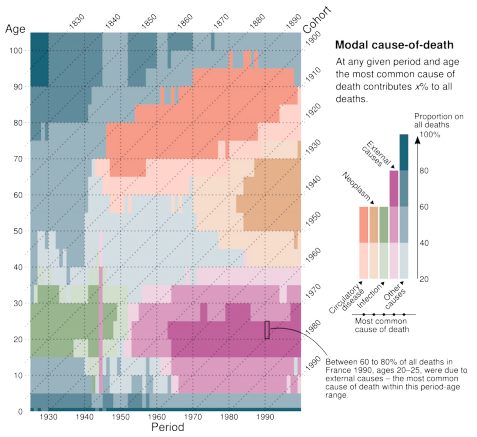
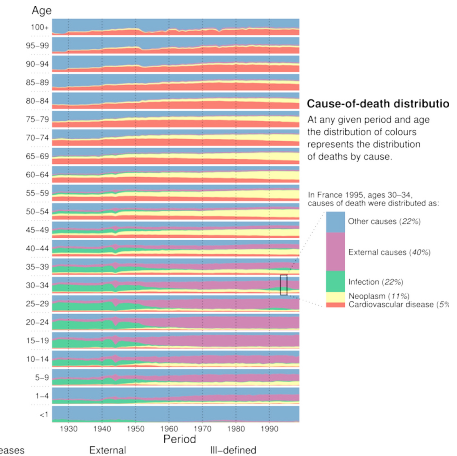






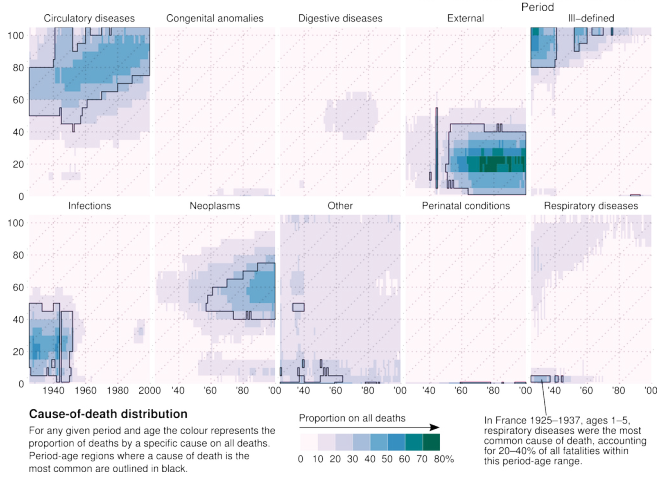
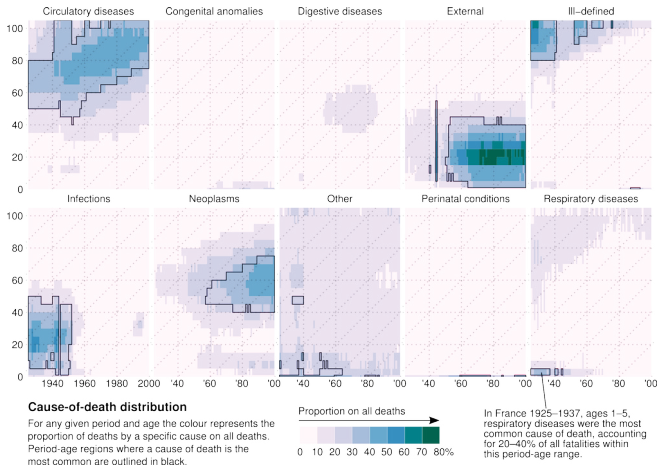


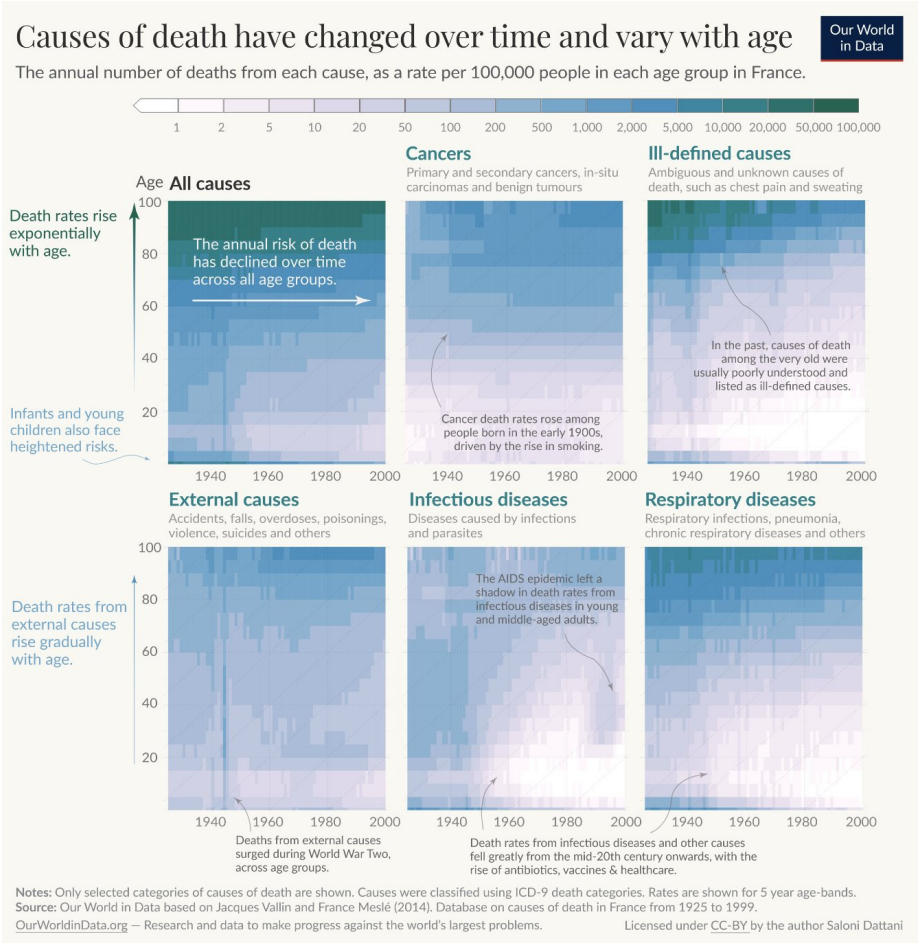
Table 1: Evaluation of different visualization techniques for compositional data on the Lexis surface

	Ternary-balance scheme	Qualitative-sequential scheme	Agewise-area plot	Small multiples
Completeness	yes	no	yes	yes
Continuity	yes	yes	no	yes
Category limit	3	≈ 5–6	≈ 8	unlimited
Pattern perception	good	good	limited	good
Table lookup	limited	limited	limited	limited
Colour-accessible	no	no	yes	yes
Footprint	small	small	small	large

Competing design goals

Schöley & Willekens (2017). Visualizing compositional data on the Lexis surface. 10.4054/DemRes.2017.36.21.

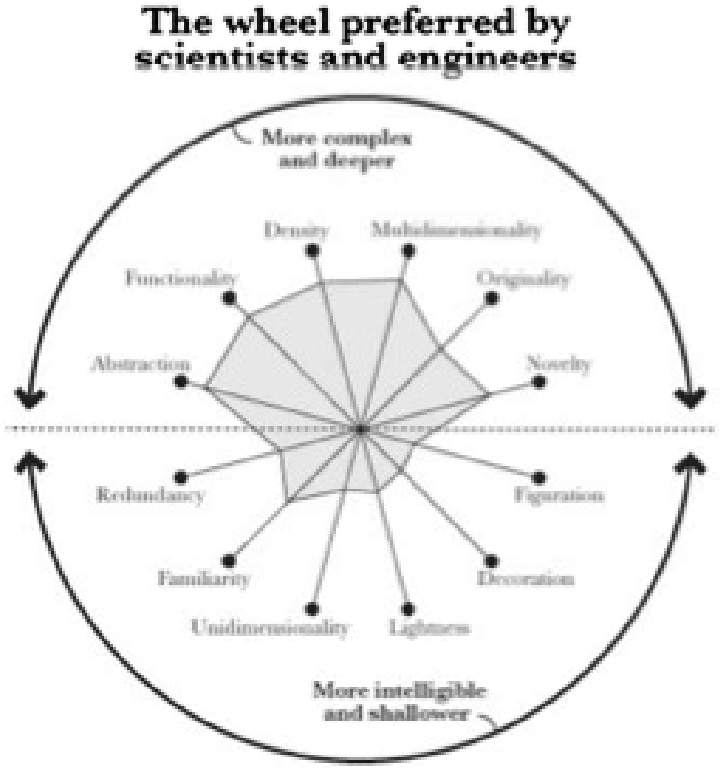


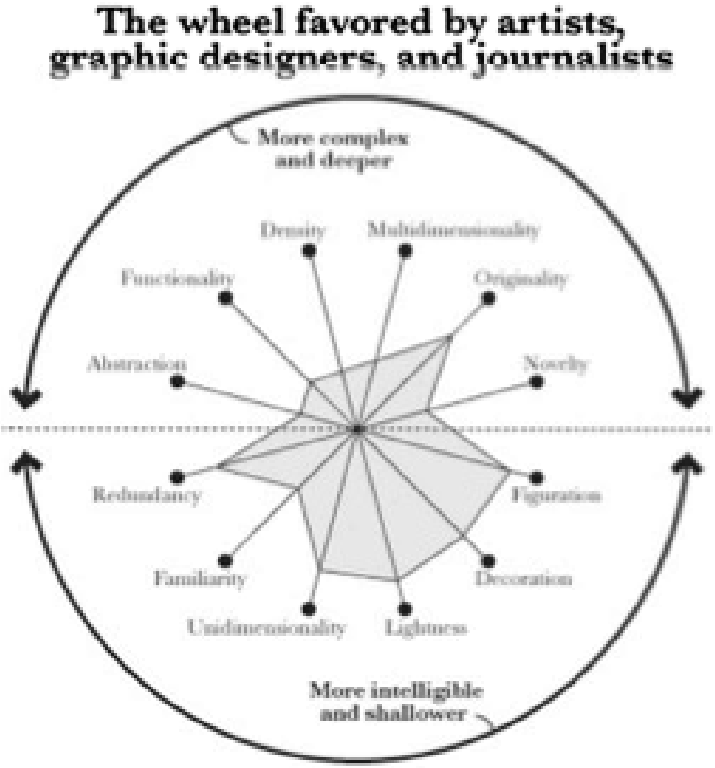


Design for your audience

Design for your audience

Cairo, A. (2012). The Functional Art.
An introduction to information graphics and visualization.
Link.

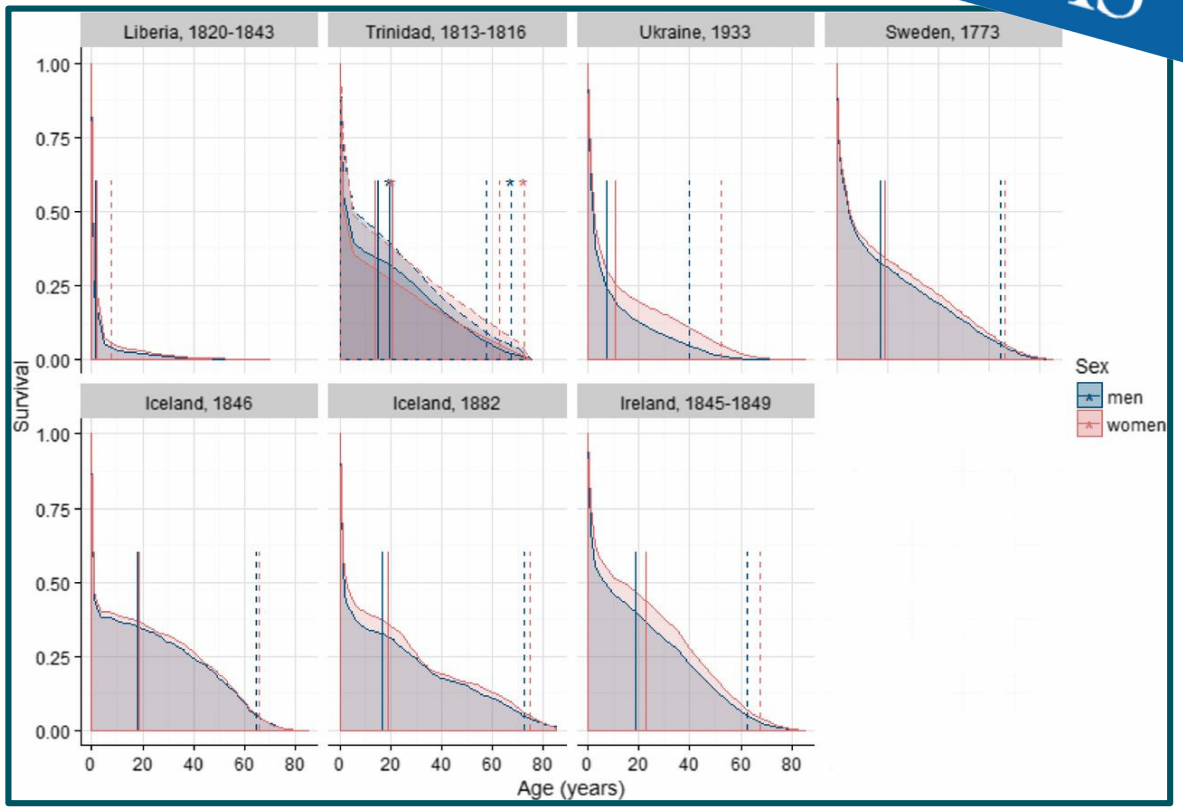




Design for your audience

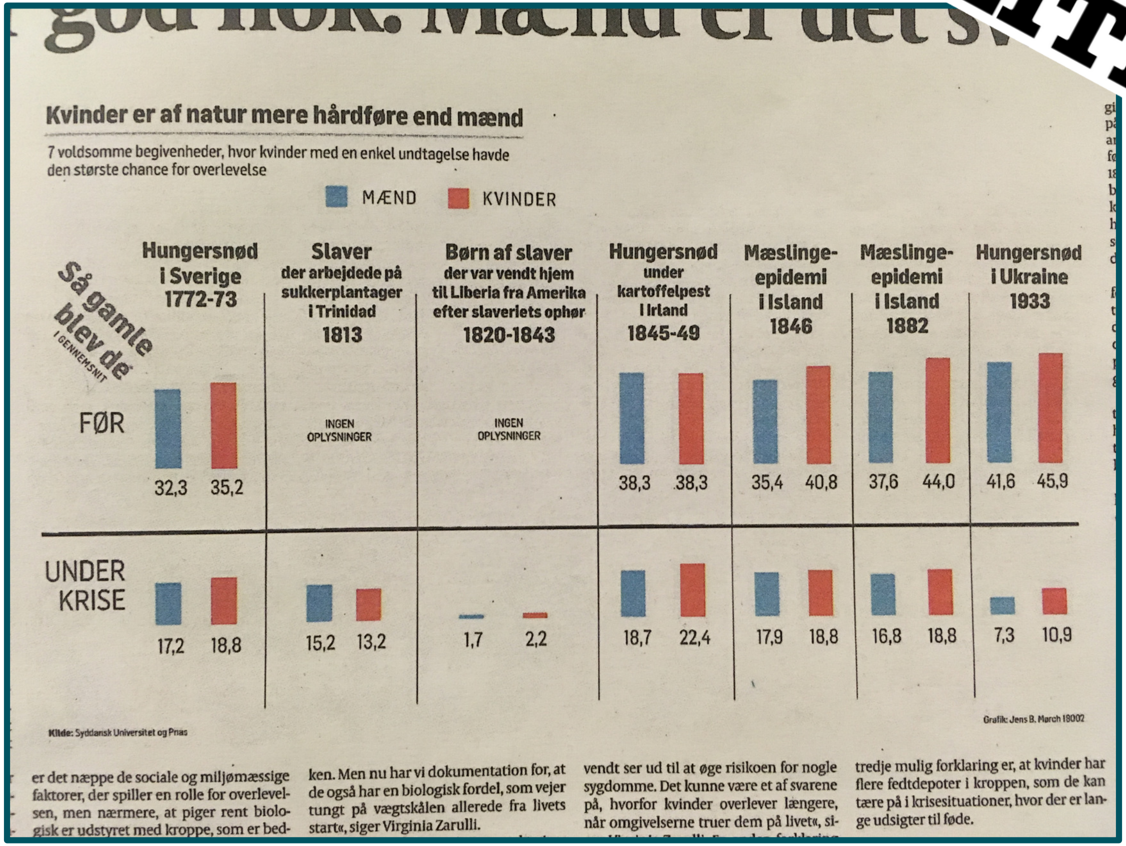
Zarulli etal. (2017). Women live longer than men even during severe famines and epidemics. 10.1073/pnas.1701535115.

PNAS Proceedings of the National Academy of Sciences of the United States of America



Design for your audience

Zarulli etal. (2017). Women live longer than men even during severe famines and epidemics. 10.1073/pnas.1701535115.



POLITIKEN Lørdag

Design for your audience

Zarulli etal. (2017). Women live longer than men even during severe famines and epidemics. 10.1073/pnas.1701535115.

Design for your audience

Schöley et al. (2021). Life expectancy changes since COVID-19. 10.1038/s41562-022-01450-3.

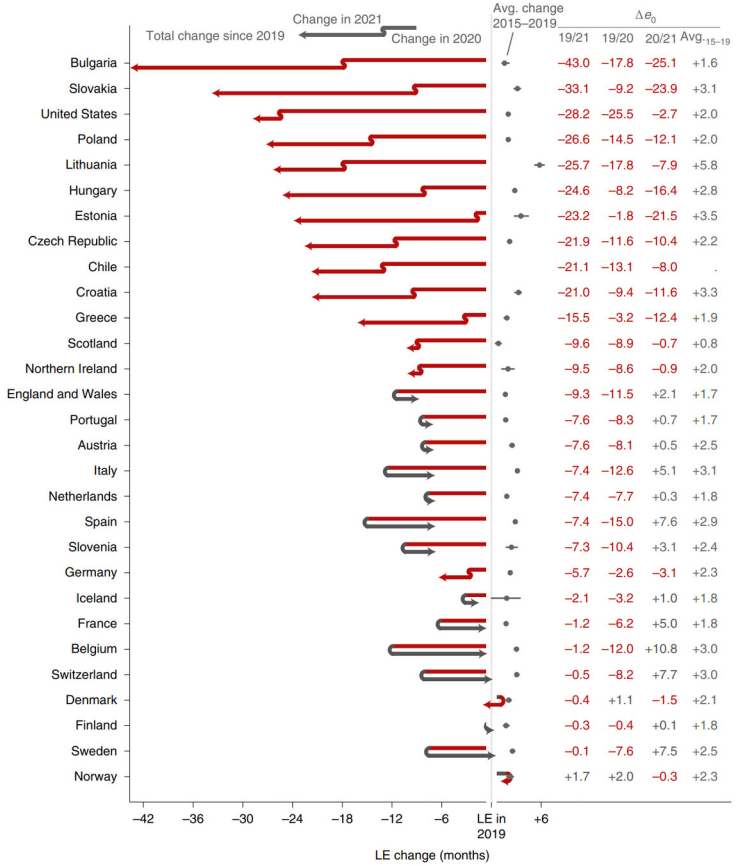
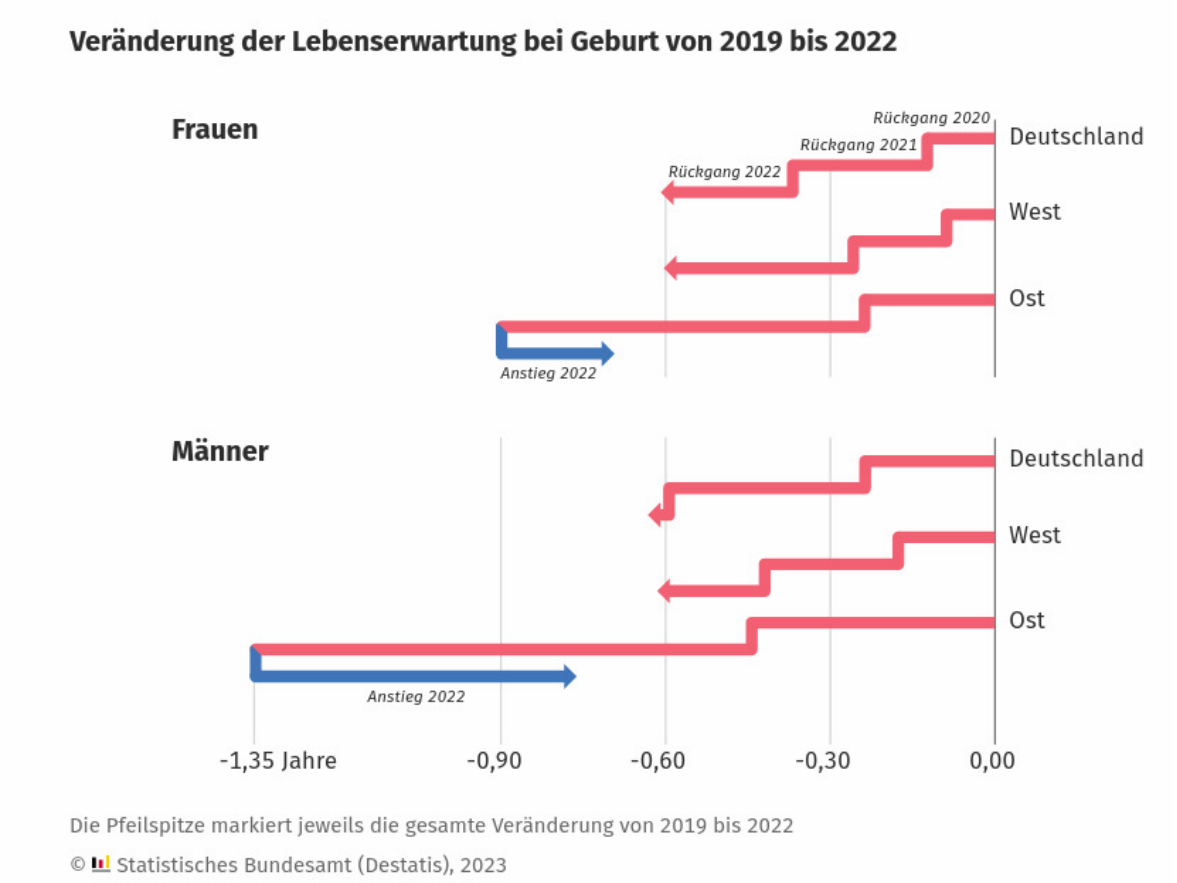


Fig. 1 | LE changes in 2019–2020 and 2020–2021 across countries. The countries are ordered by increasing cumulative LE losses since 2019. The two line segments indicate the annual changes in LE in 2020 and 2021. Red segments to the left indicate an LE drop, while grey arrows to the right indicate a rise in LE. The position of the arrowhead indicates the total change in LE from 2019 through 2021. The grey dots and lines indicate the average annual LE changes over the years 2015 through 2019 along with 95% CIs. Δe_0 marks the change in period LE over the designated period.

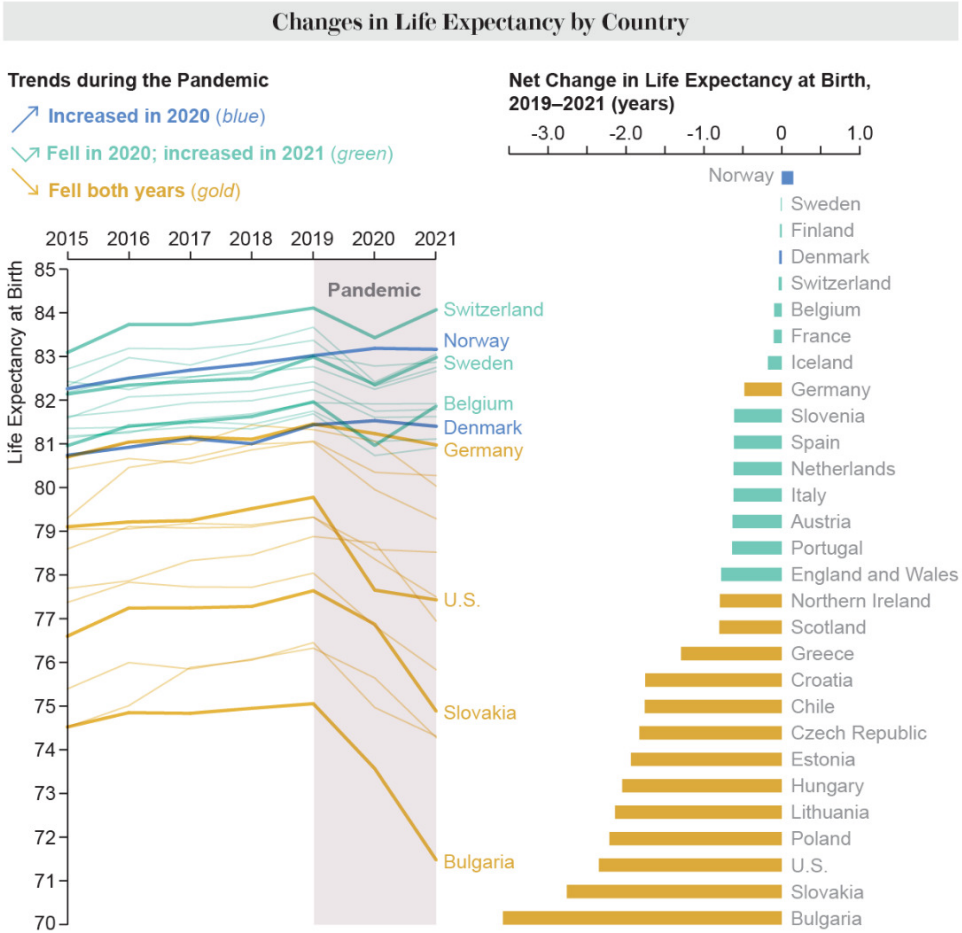
Design for your audience

Statistisches Bundesamt (2023). Veränderung der Lebenserwartung bei Geburt.



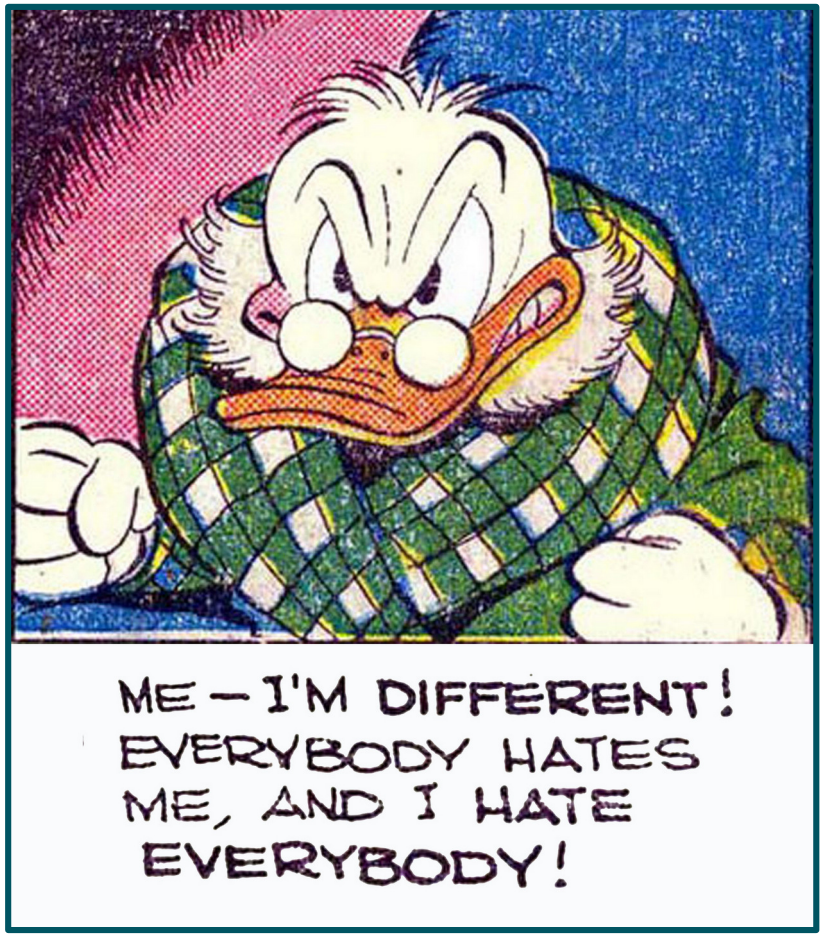
Design for your audience

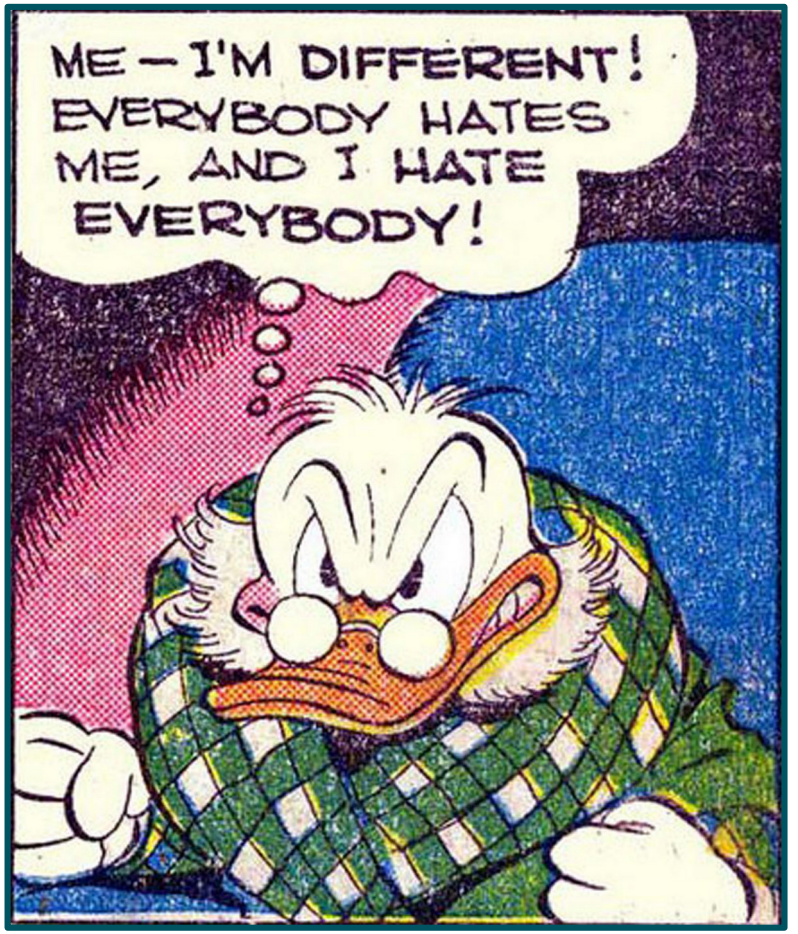
Tanya Lewis for Scientific American (2022).
Why Life Expectancy Keeps Dropping in the U.S.



Design for the medium

Design for the medium paper (direct annotation)





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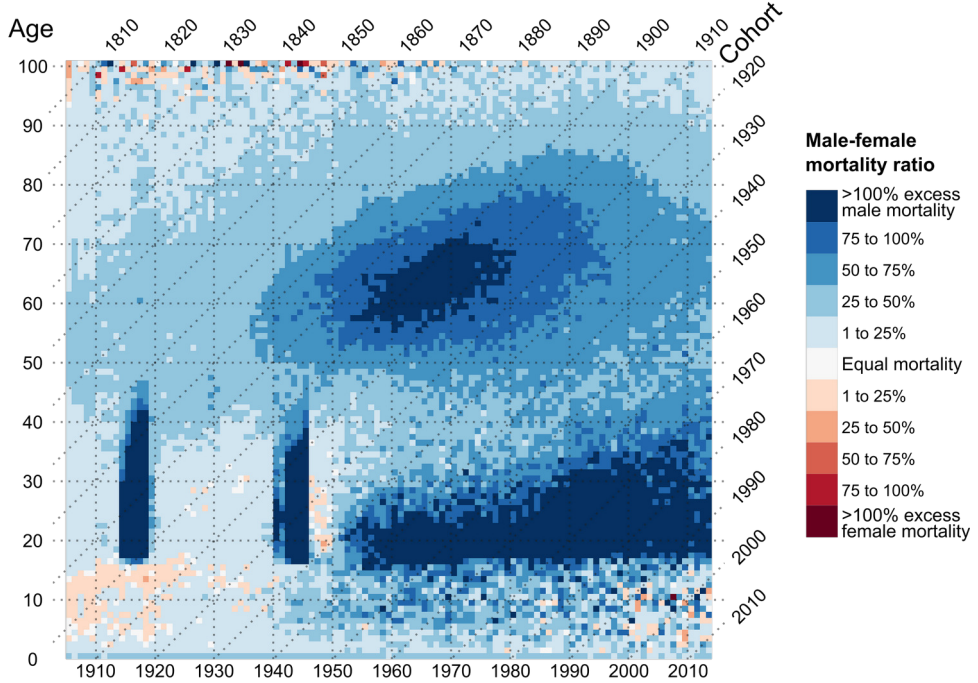


Figure 1: Age-specific excess-male mortality in England & Wales 1905 to 2013. Clearly visible is the male mortality related to World War I (1914–1918) and World War II (1939–1945). Conscription was introduced in March 1916 and applied to men aged 18–40. Smoking-related excess mortality among male cohorts born prior to World War II shows as a elliptical region above age 50. In later cohorts women's smoking habits caught up with thoseof men, counterbalancing the male deaths. Great successes in combating infectious diseases reduce early adult mortality for both sexes. Young men remain at a higher risk for accidents, which contributes to their excess mortality since the mid 1950s.

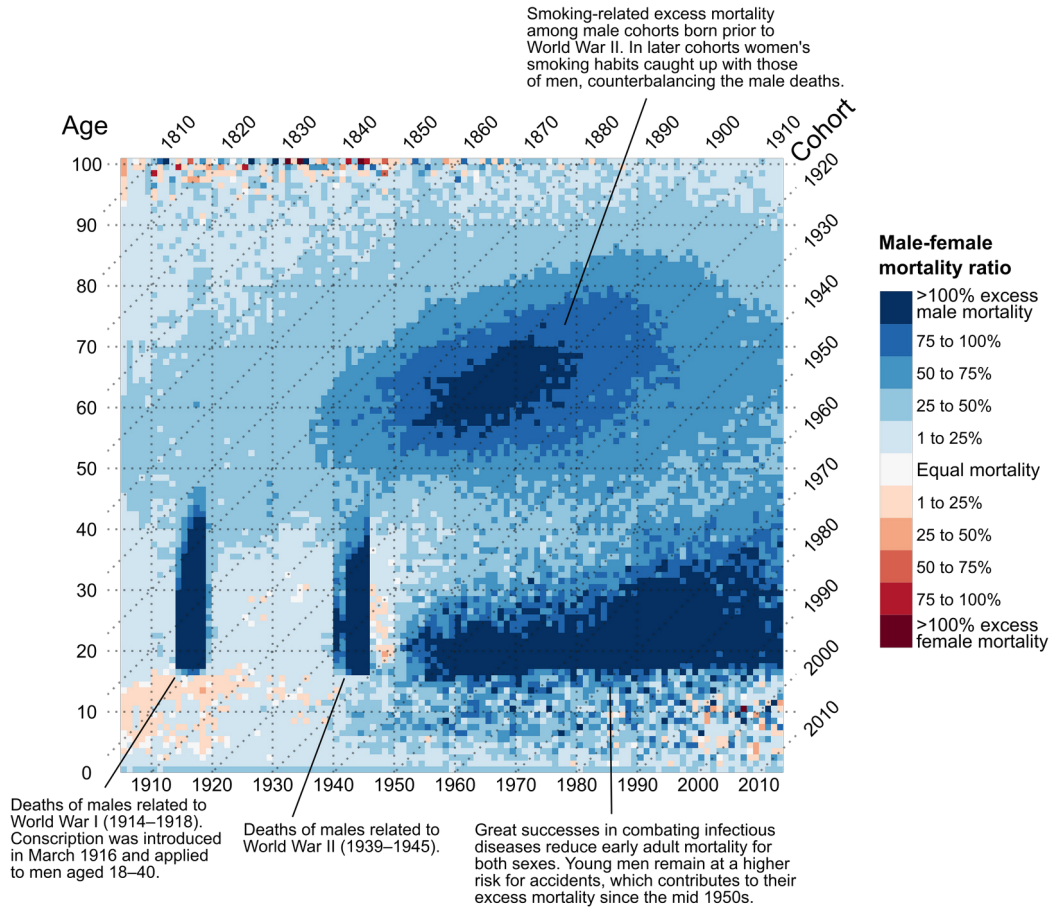


Figure 1: Age-specific excess-male mortality in England & Wales 1905 to 2013.

Design for the medium paper (direct annotation)

Figure 3: Age trajectories of feto-infant survival A) by sex for the U.S. conception cohort 2009, B) by U.S. conception cohort, C) by maternal origin for the U.S. conception cohort 2009. Fitted (lines) versus lifetable estimates (points).

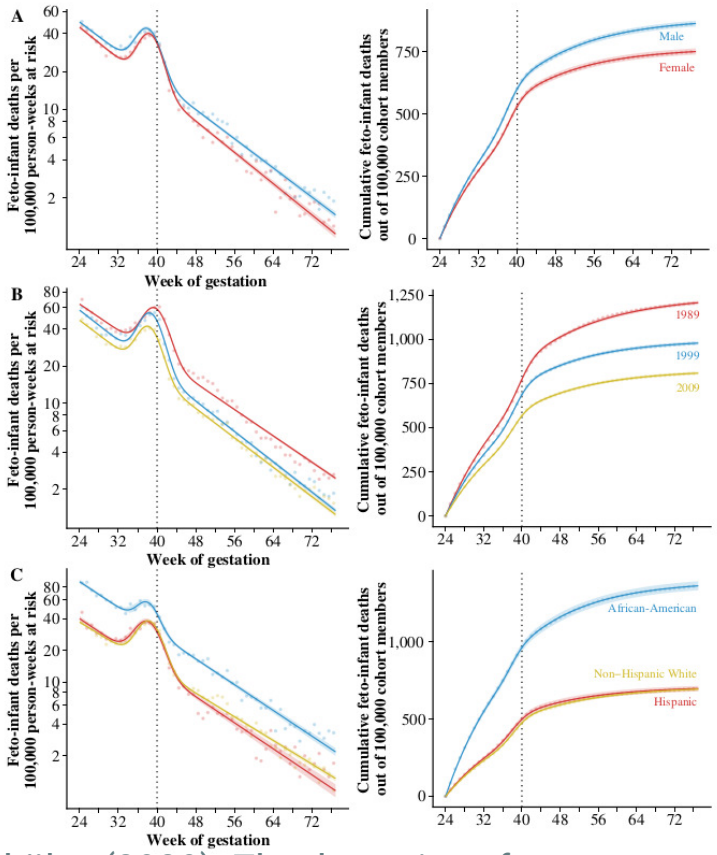
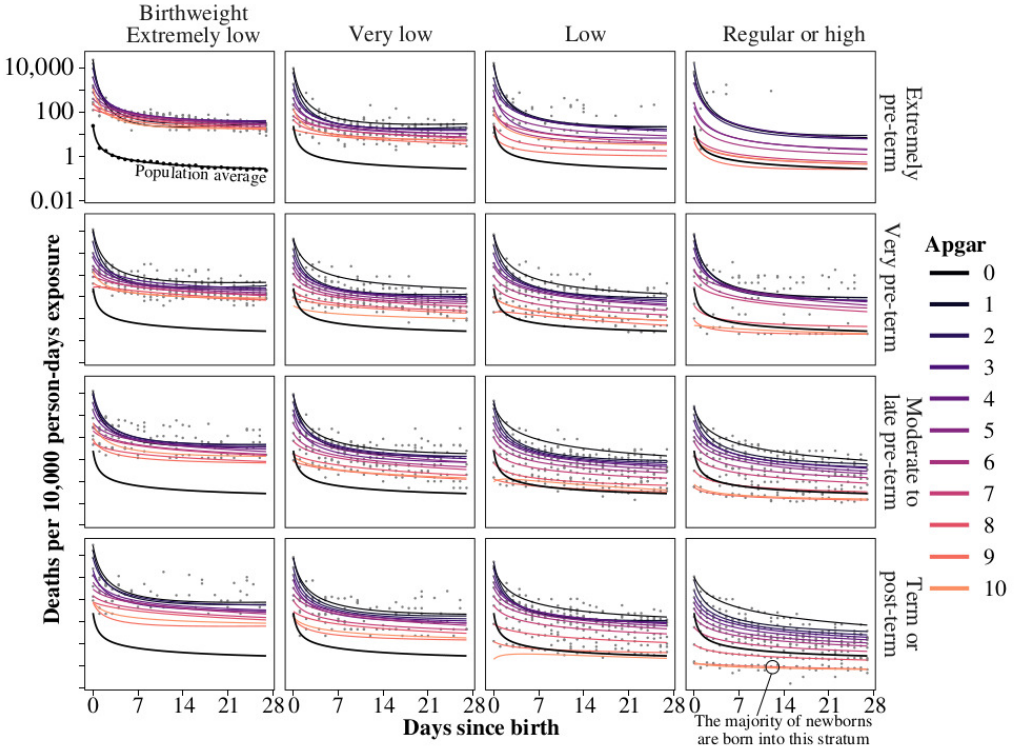


Figure 3: Estimated hazard rates versus life table mortality rates over age by prematurity, birth weight, and Apgar score. There is substantial heterogeneity in the level and the shape of the neonatal hazard trajectories ruling out the hypothesis of proportional frailties. The black line in each panel shows the estimated hazard trajectory for the entire birth cohort.



Schöley (2020). The dynamics of ontogenescence. Github.

Design for the medium paper

Schöley et al. (2021). Life expectancy changes since COVID-19. 10.1038/s41562-022-01450-3.

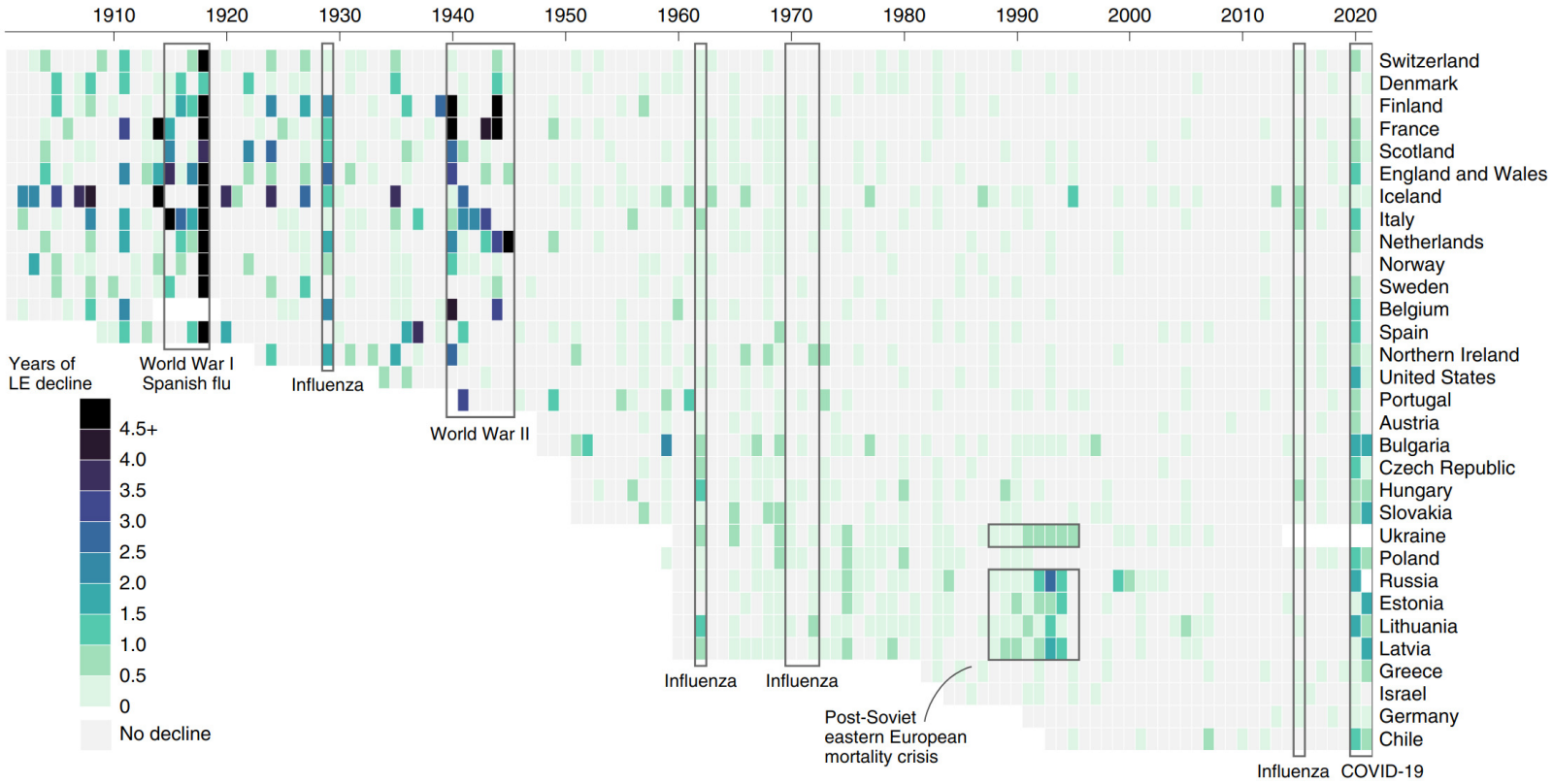
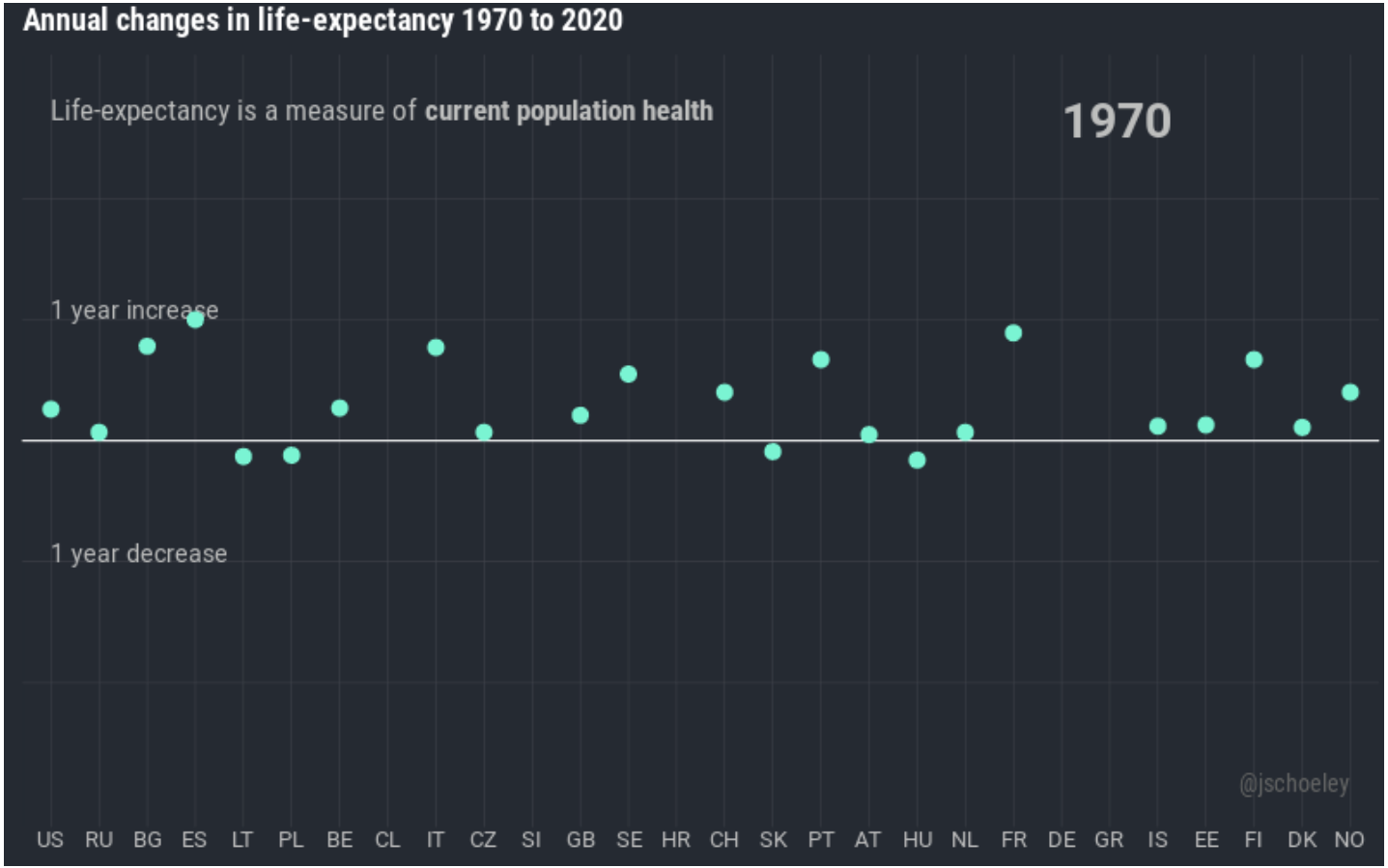


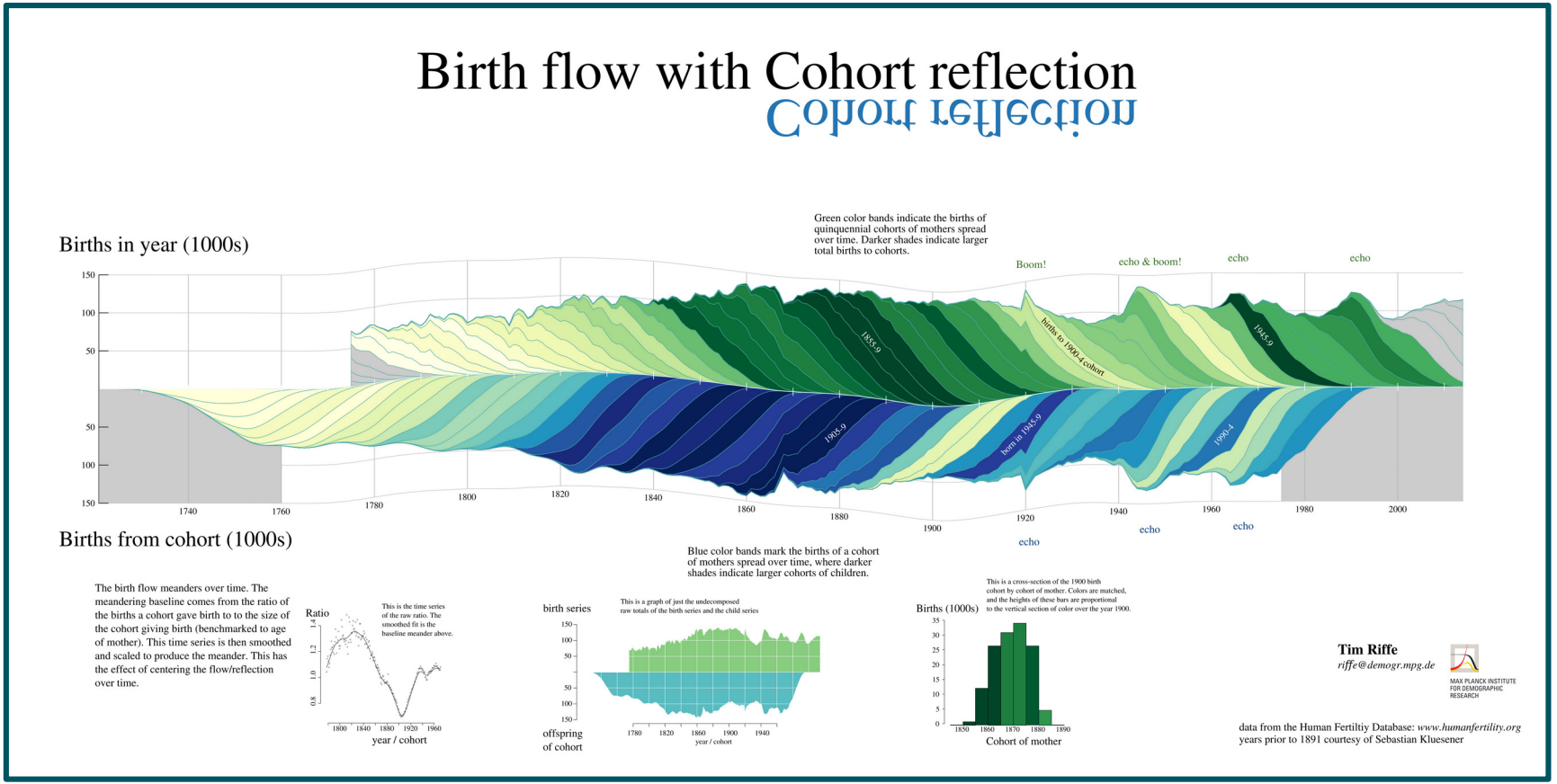
Fig. 6 | Annual LE declines since 1900. Period shocks to LE due to wars and epidemics show up as green vertical bands across countries, momentarily disrupting the dominant trend of expectancy improvements, shown in grey.

Design for the medium social media

Schöley (2021) Annual changes In life-expectancy 1970 to 2020. Tweet. Github.

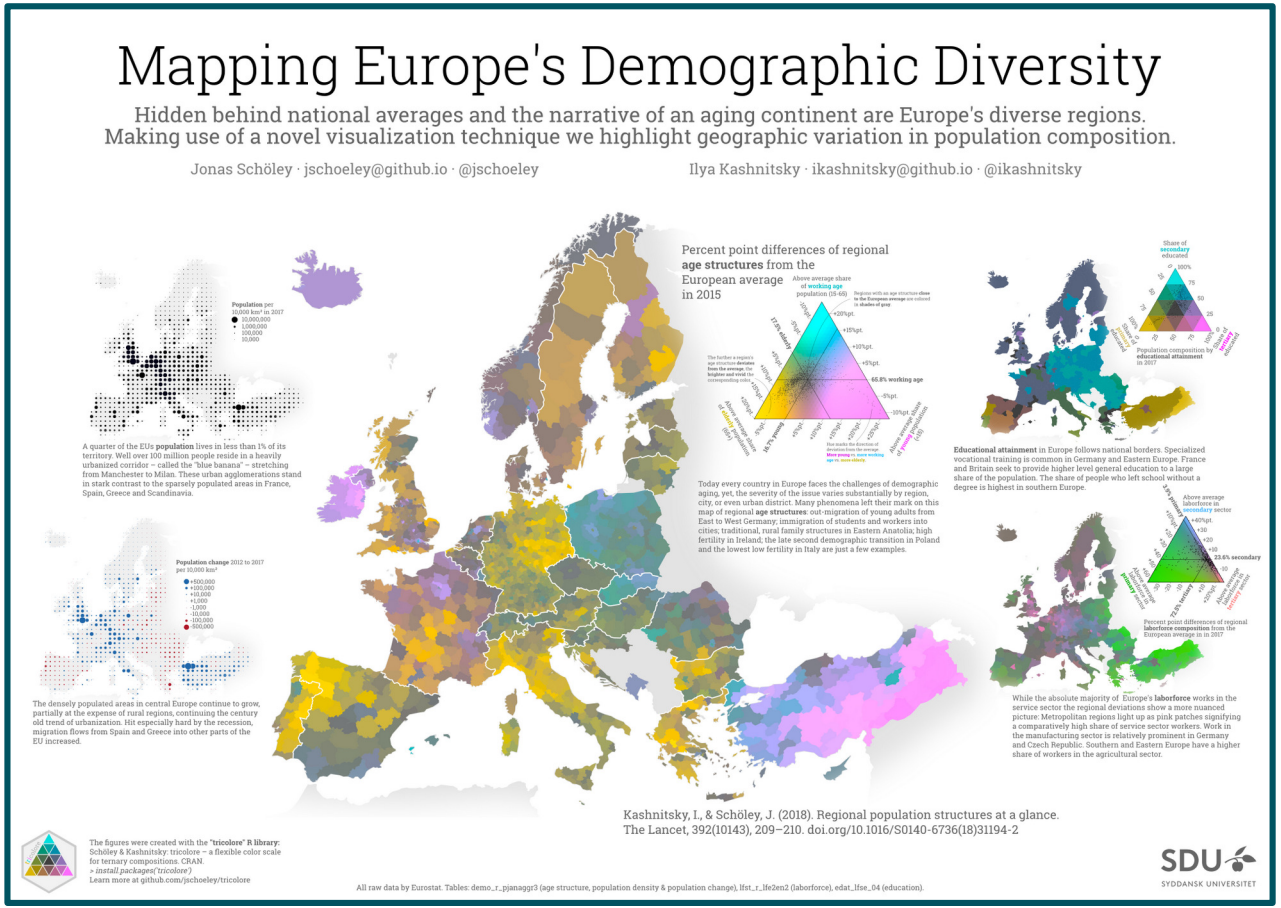


Design for the medium poster



Tim Riffe (2017). Birth flow with Cohort reflection. Github.

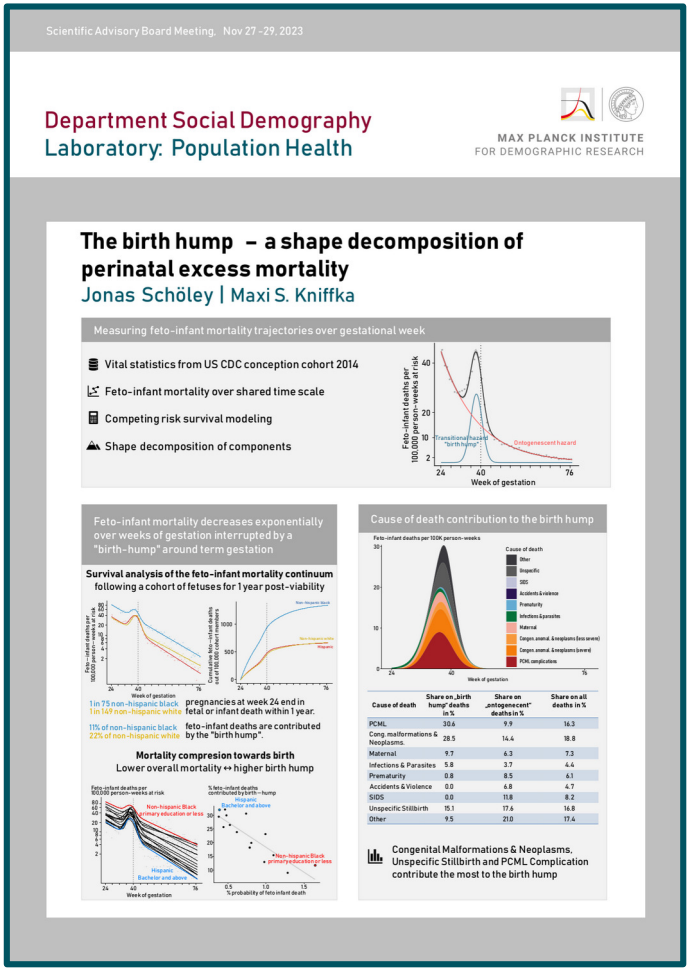
Design for the medium poster



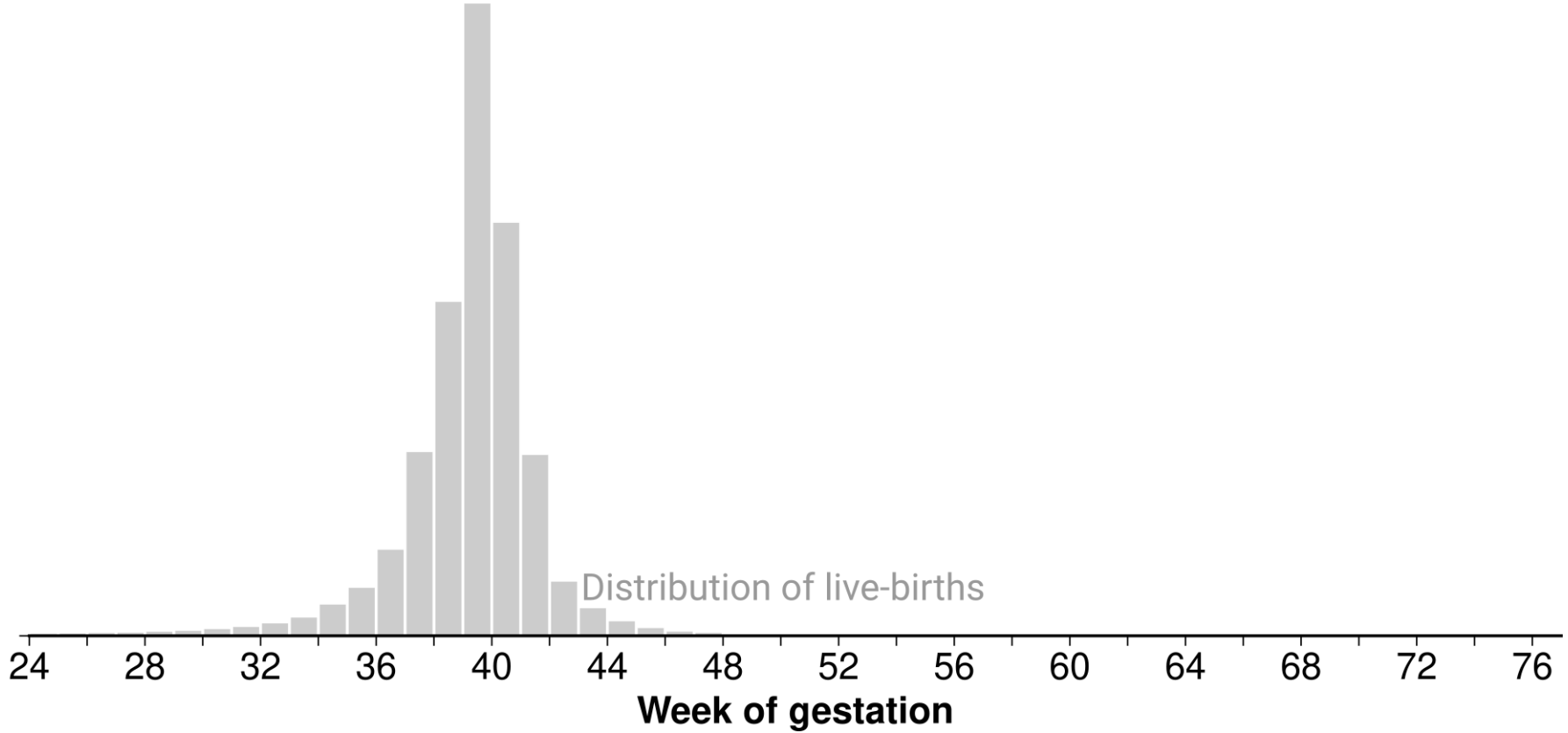
Schöley & Kashnitsky (2018). Mapping Europe's Demographic Diversity. Github.

Design for the medium poster

Schöley & Kniffka (2023).
The birth hump. Github.

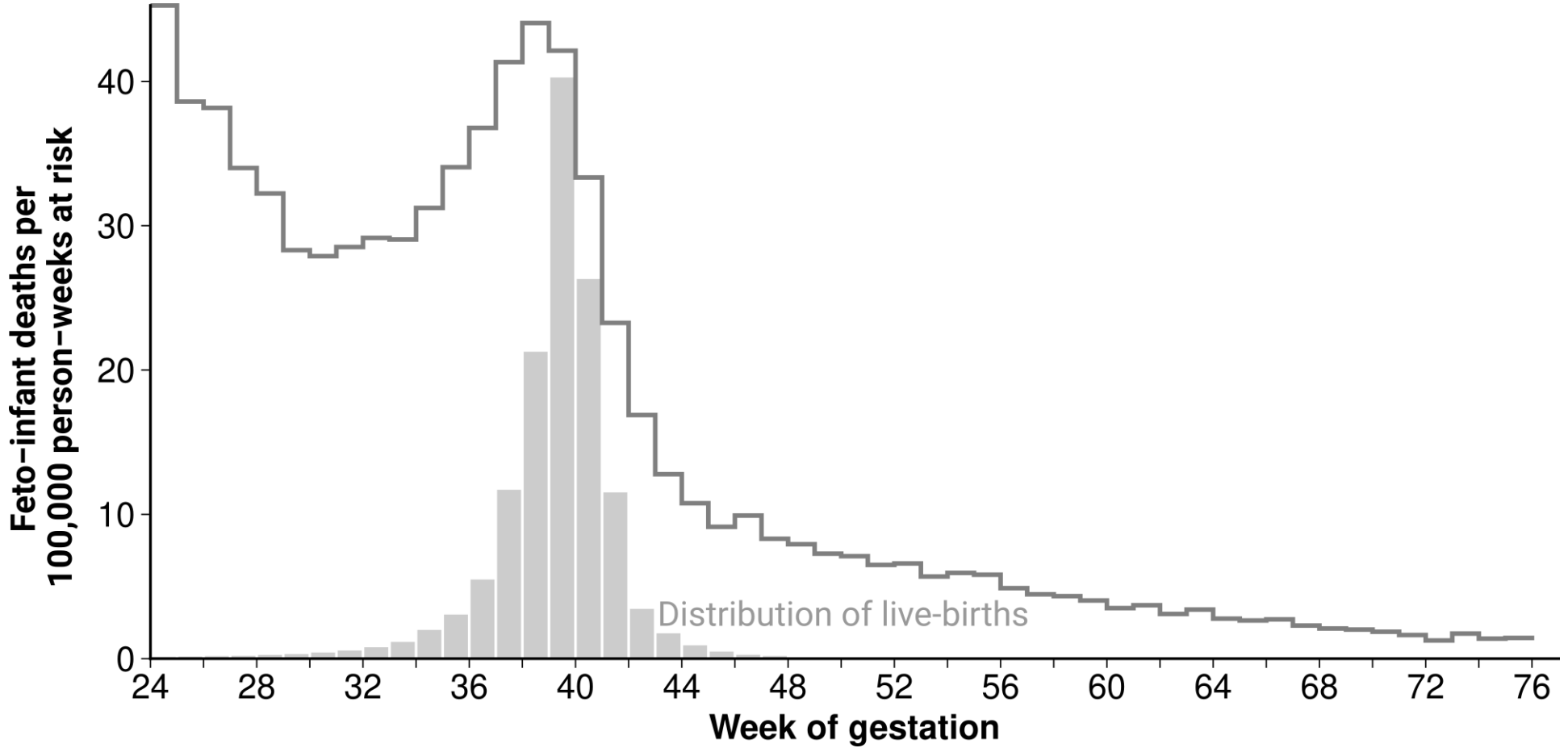


Design for the medium presentation



Schöley (2023). Combined feto-infant mortality by week of gestation among conception cohort 2014. Github.

Design for the medium presentation



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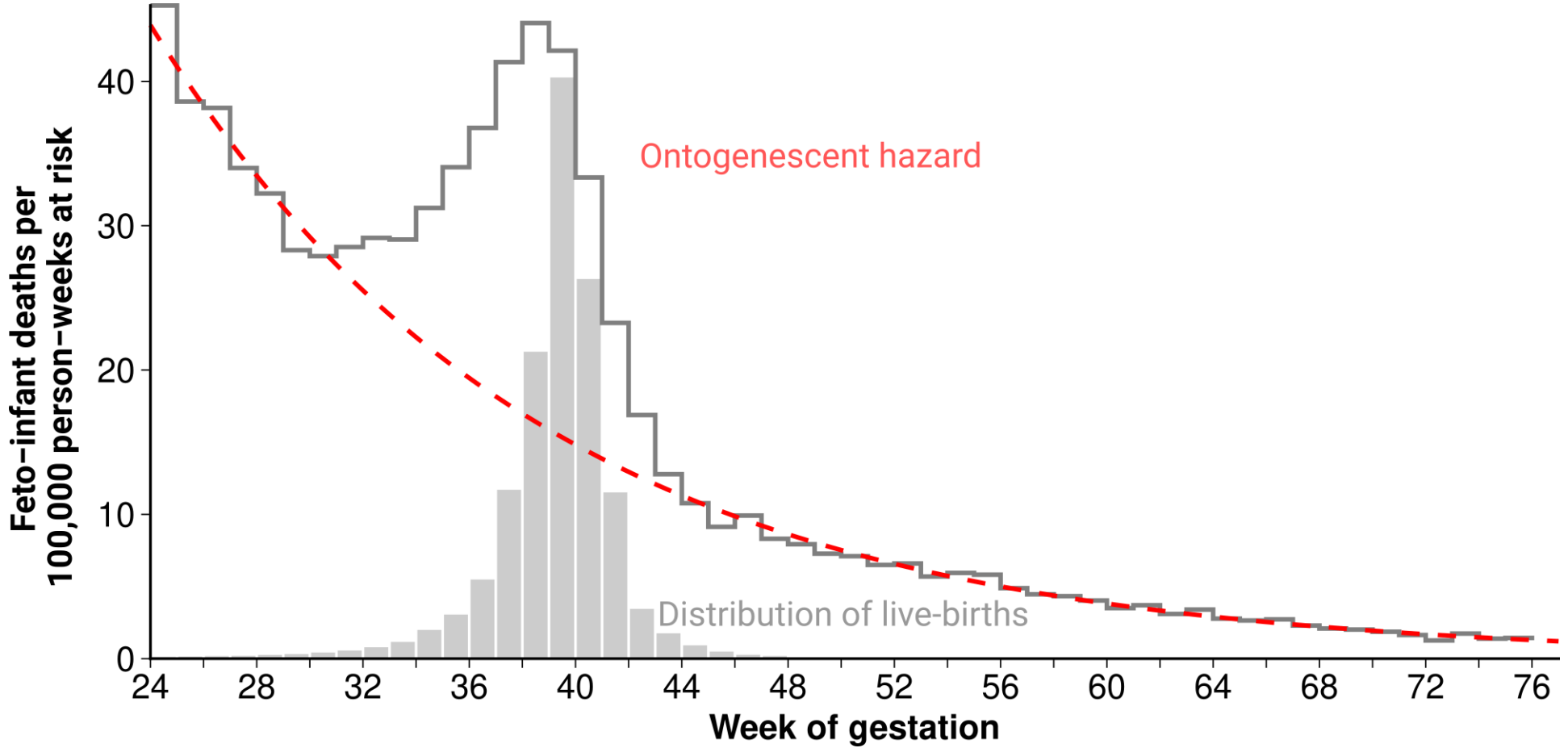
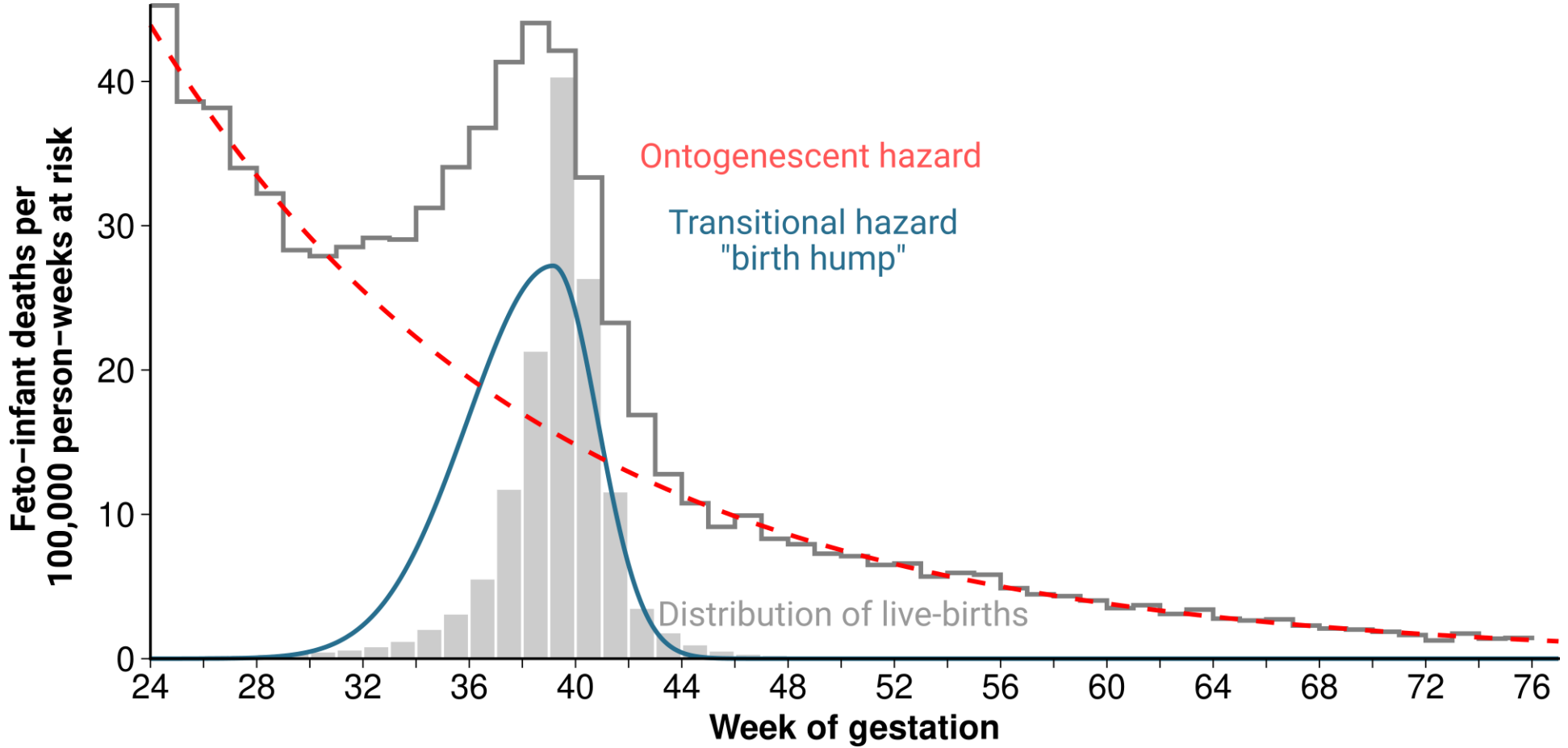
Design for the medium presentation



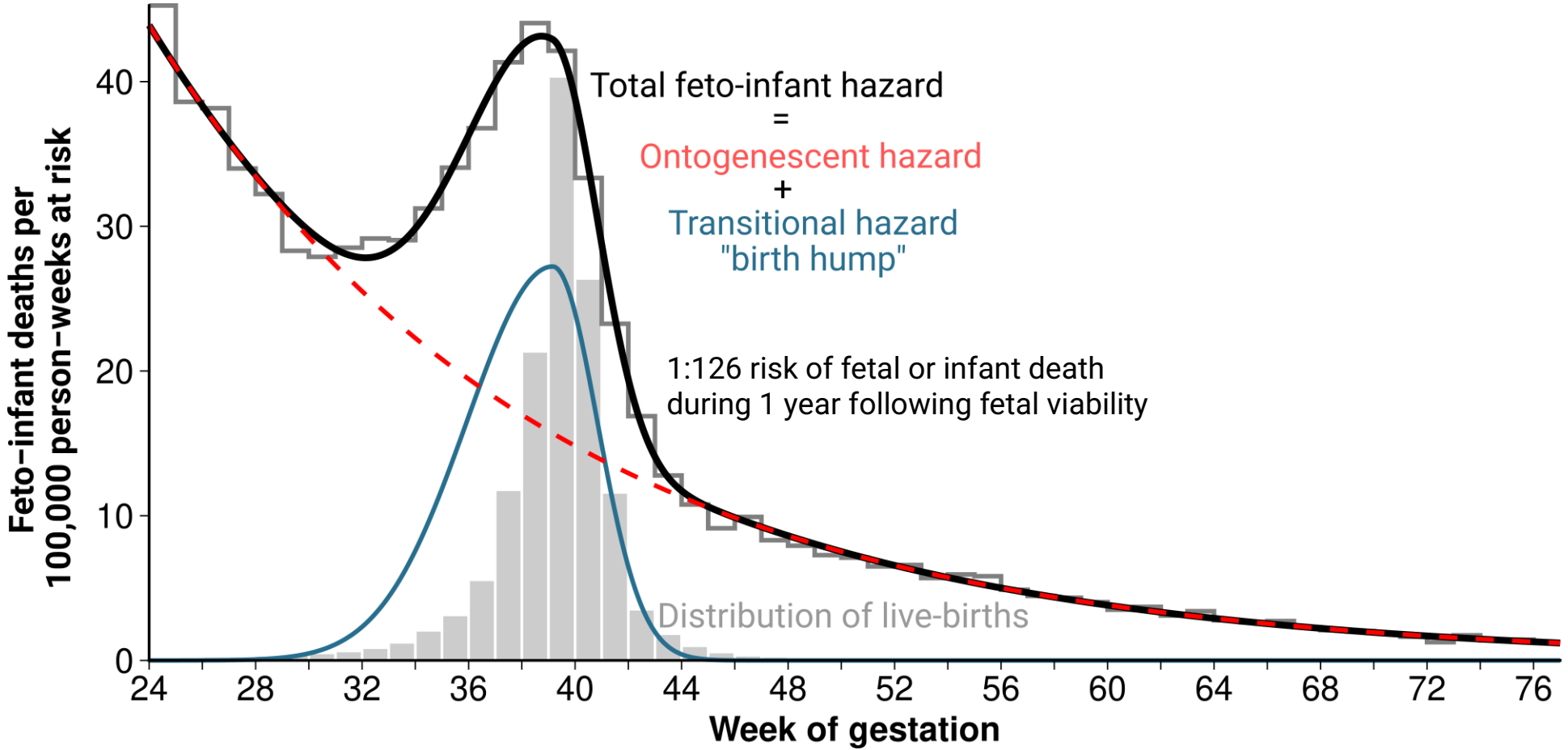
Schöley (2023). Combined feto-infant mortality by week of gestation among conception cohort 2014. Github.

Design for the medium presentation



Schöley (2023). Combined feto-infant mortality by week of gestation among conception cohort 2014. Github.

Design for the medium presentation



Schöley (2023). Combined feto-infant mortality by week of gestation among conception cohort 2014. Github.

Design for the medium presentation

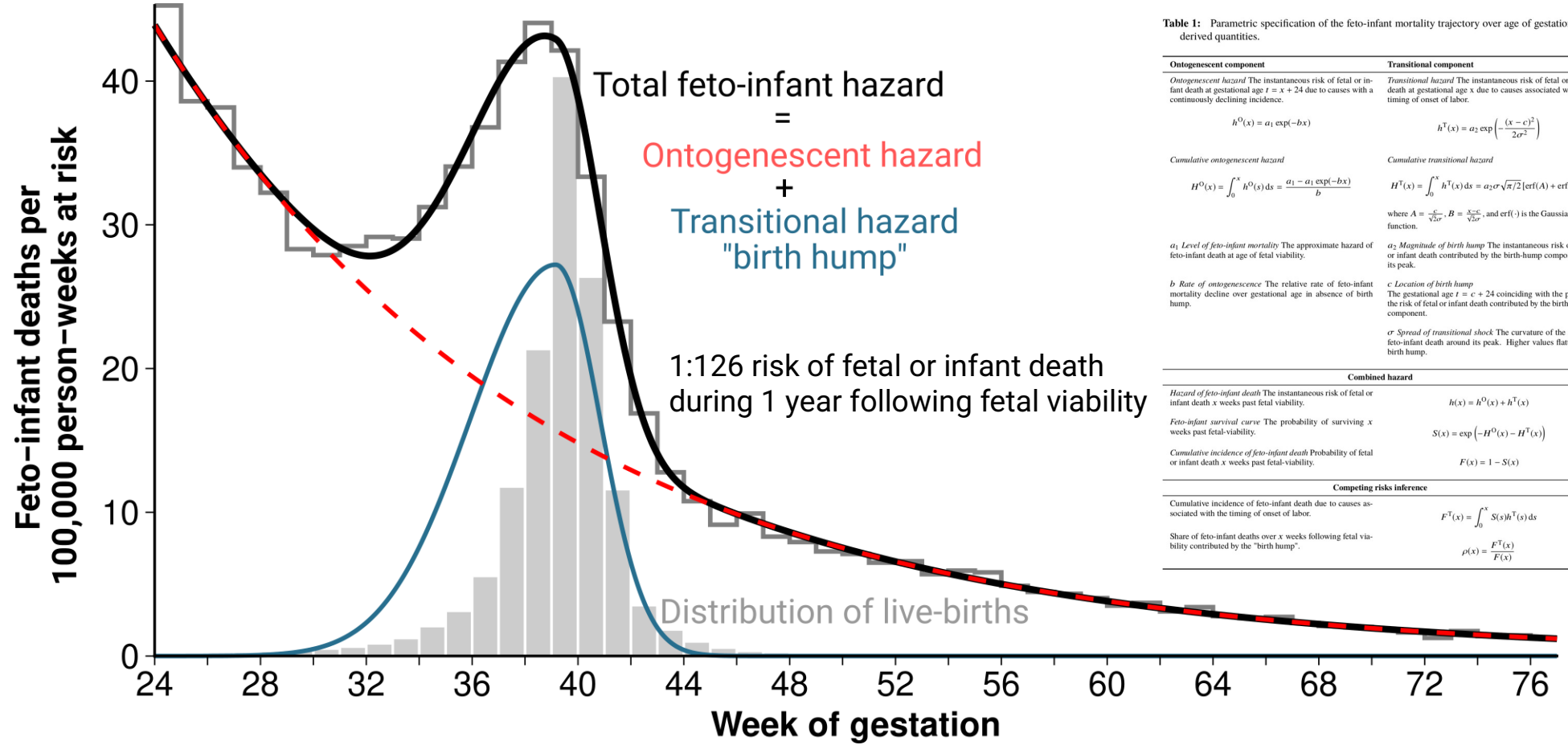


Table 1: Parametric specification of the feto-infant mortality trajectory over age of gestation and derived quantities.

Ontogenescent component	**Transitional component**
Ontogenescent hazard The instantaneous risk of fetal or infant death at gestational age $t = x + 24$ due to causes with a continuously declining incidence. $h^{O}(x) = a_1 \exp(-bx)$	*Transitional hazard* The instantaneous risk of fetal or infant death at gestational age x due to causes associated with the timing of onset of labor. $h^{T}(x) = a_2 \exp\left(-\frac{(x-c)^2}{2\sigma^2}\right)$
Cumulative ontogenescent hazard $H^{O}(x) = \int_0^x h^{O}(s)\,ds = \frac{a_1 - a_1 \exp(-bx)}{b}$	*Cumulative transitional hazard* $H^{T}(x) = \int_0^x h^{T}(x)\,ds = a_2\sigma\sqrt{\pi/2}\,[\mathrm{erf}(A) + \mathrm{erf}(B)]$, where $A = \frac{-c}{\sqrt{2}\sigma}$, $B = \frac{x-c}{\sqrt{2}\sigma}$, and $\mathrm{erf}(\cdot)$ is the Gaussian error function.
a_1 *Level of feto-infant mortality* The approximate hazard of feto-infant death at age of fetal viability.	a_2 *Magnitude of birth hump* The instantaneous risk of fetal or infant death contributed by the birth-hump component at its peak.
b *Rate of ontogenescence* The relative rate of feto-infant mortality decline over gestational age in absence of birth hump.	c *Location of birth hump* The gestational age $t = c + 24$ coinciding with the peak of the risk of fetal or infant death contributed by the birth-hump component.
	σ *Spread of transitional shock* The curvature of the risk of feto-infant death around its peak. Higher values flatten the birth hump.
Combined hazard	
Hazard of feto-infant death The instantaneous risk of fetal or infant death x weeks past fetal viability.	$h(x) = h^{O}(x) + h^{T}(x)$
Feto-infant survival curve The probability of surviving x weeks past fetal-viability.	$S(x) = \exp\left(-H^{O}(x) - H^{T}(x)\right)$
Cumulative incidence of feto-infant death Probability of fetal or infant death x weeks past fetal-viability.	$F(x) = 1 - S(x)$
Competing risks inference	
Cumulative incidence of feto-infant death due to causes associated with the timing of onset of labor.	$F^{T}(x) = \int_0^x S(s)h^{T}(s)\,ds$
Share of feto-infant deaths over x weeks following fetal viability contributed by the "birth hump".	$\rho(x) = \frac{F^{T}(x)}{F(x)}$

Schöley (2023). Combined feto-infant mortality by week of gestation among conception cohort 2014. Github.

Good Visualizations are designed
with a clear purpose, for a specific audience
and for a specific medium

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