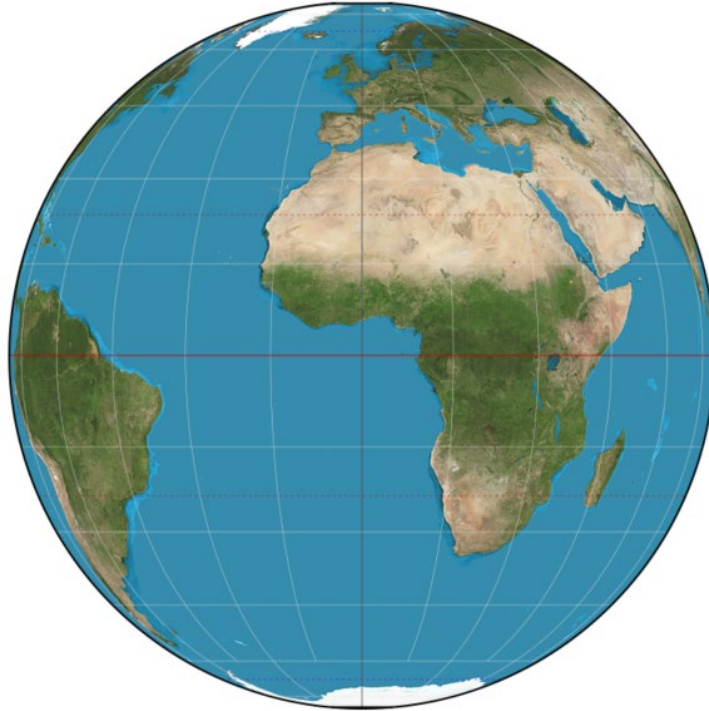# Cognition and Perception of Map Projections

Fritz Kessler
Penn State University

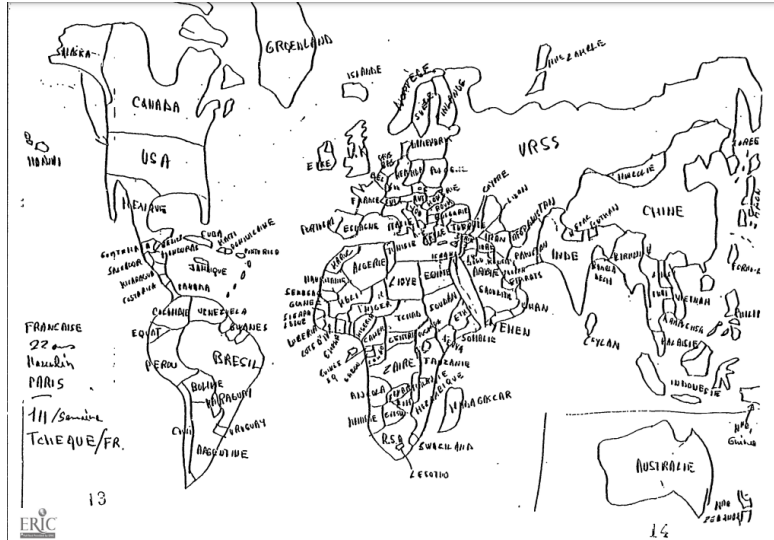**Sarah Battersby**
Tableau Research
Salesforce, Inc.

Cognition, perception, and map projections

Why?

What is the impact of stimulus / study structure?

How we phrase questions & externalize spatial data makes a difference
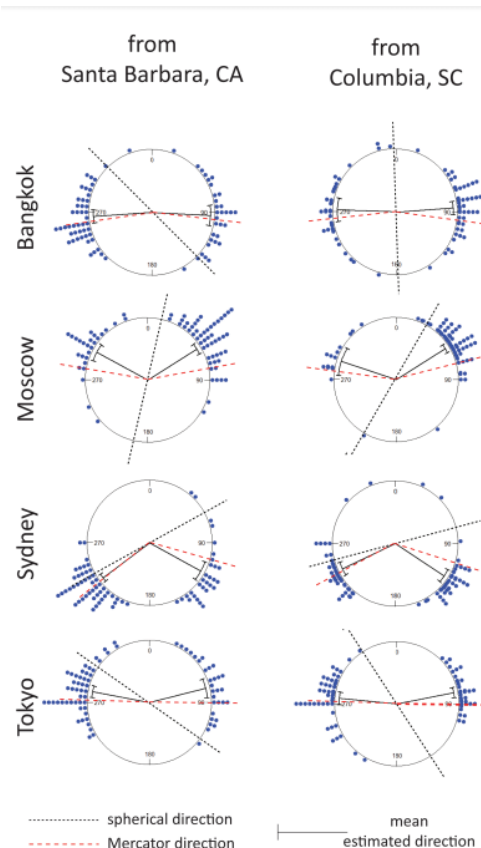

Saarinen 1987

Zak Ziebell collection
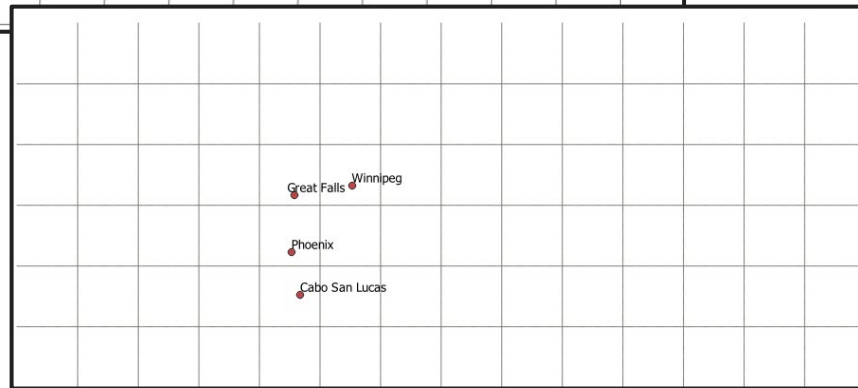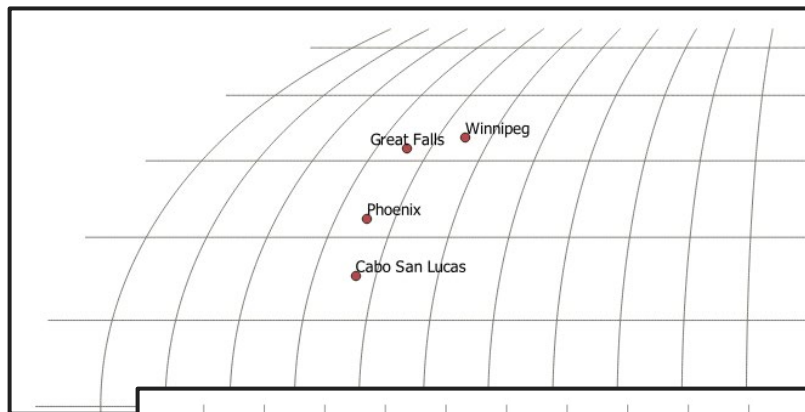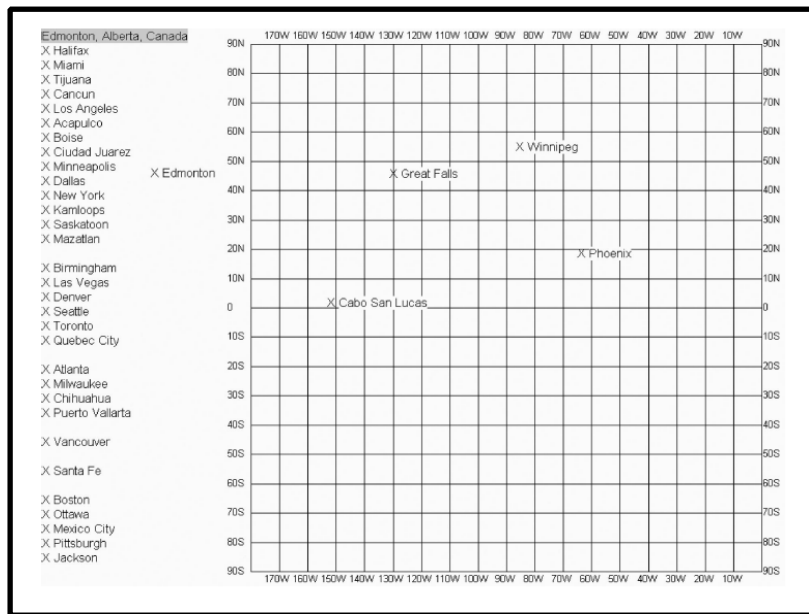
What is the impact of stimulus / study structure?

"Estimate spherical direction, *as a jet would fly…*"
(Montello & Battersby 2022)

Montello & Battersby 2022

What is the impact of stimulus / study structure?

Plot / draw the location of…

Edmonton, Alberta, Canada
X Halifax
X Miami
X Tijuana
X Cancun
X Los Angeles
X Acapulco
X Boise
X Ciudad Juarez
X Minneapolis
X Dallas
X New York
X Kamloops
X Saskatoon
X Mazatlan

X Birmingham
X Las Vegas
X Denver
X Seattle
X Toronto
X Quebec City

X Atlanta
X Milwaukee
X Chihuahua
X Puerto Vallarta

X Vancouver

X Santa Fe

X Boston
X Ottawa
X Mexico City
X Pittsburgh
X Jackson

How do we analyze?

What is the gold standard? Spherical? Planar? What projection?

And what if the experimenter gets it a little bit wrong?

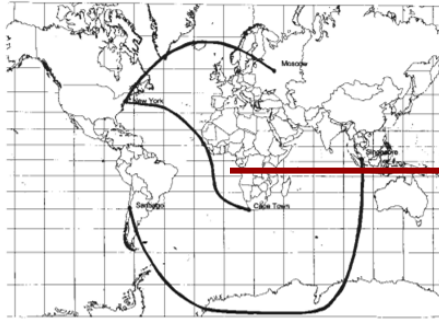FIGURE 3   Correct solutions to the three tasks involving a map of the world with a Mercator projection.
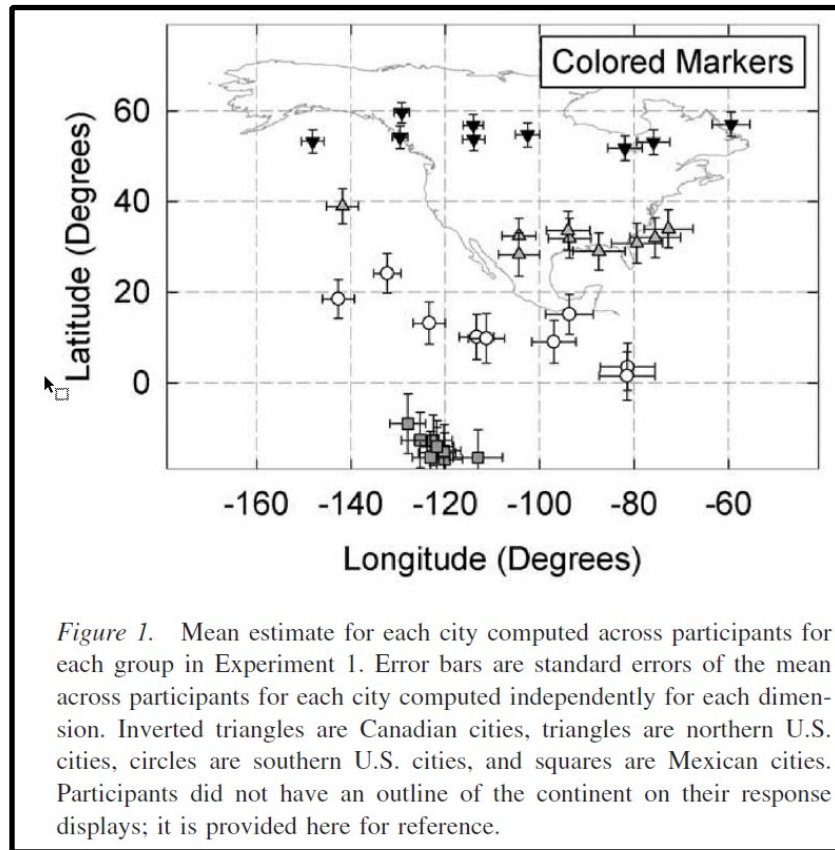
Anderson & Leinhardt 2002

How do we analyze?

Visual analysis is important…but

Error bars for latitude & longitude

Can you visually compare the error bars between latitude and longitude? No.

Turns out the meaning of a degree isn't equal here

Figure 1. Mean estimate for each city computed across participants for each group in Experiment 1. Error bars are standard errors of the mean across participants for each city computed independently for each dimension. Inverted triangles are Canadian cities, triangles are northern U.S. cities, circles are southern U.S. cities, and squares are Mexican cities. Participants did not have an outline of the continent on their response displays; it is provided here for reference.

Friedman 2009

Educational challenges: Transferability of "rules"

"the line should be curved"
(true in some cases, not in others)
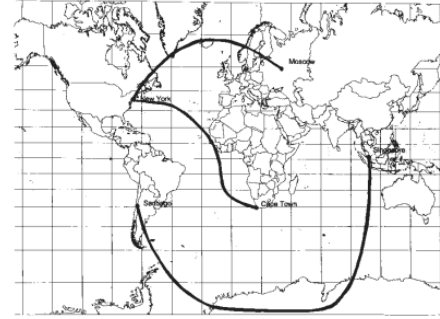
Anderson and Leinhardt (2002)

FIGURE 3 Correct solutions to the three tasks involving a map of the world with a Mercator projection.

FIGURE 4 Correct solutions to the two tasks involving a map of the Americas with a Mercator projection.

Anderson & Leinhardt 2002

Something is happening at the edge…

Why are you drawing the line the *wrong way?*

Educational challenges: Transferability of "rules"

"Antarctica and Greenland are too big"
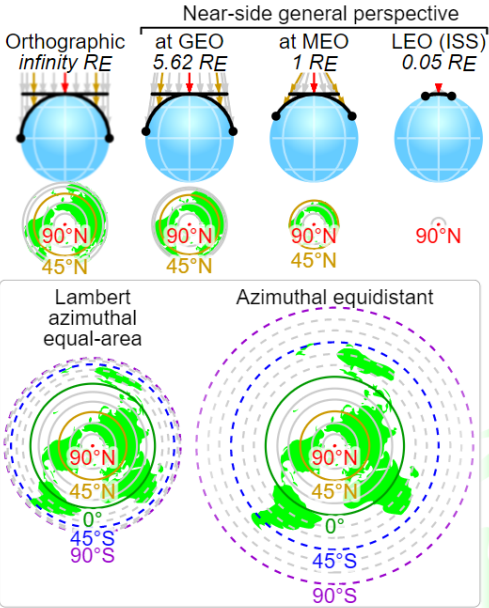(true in some cases…not in others)

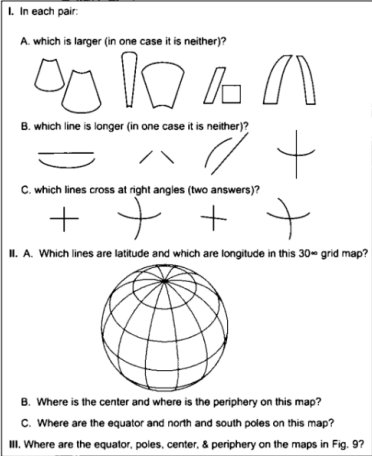Battersby & Kessler (2012)

ps - Robinson also just "looks right"
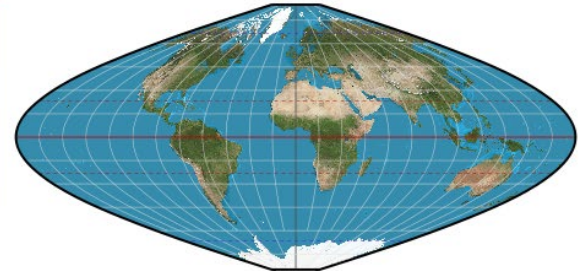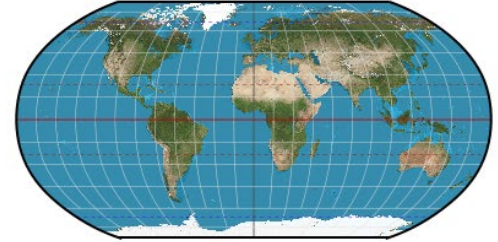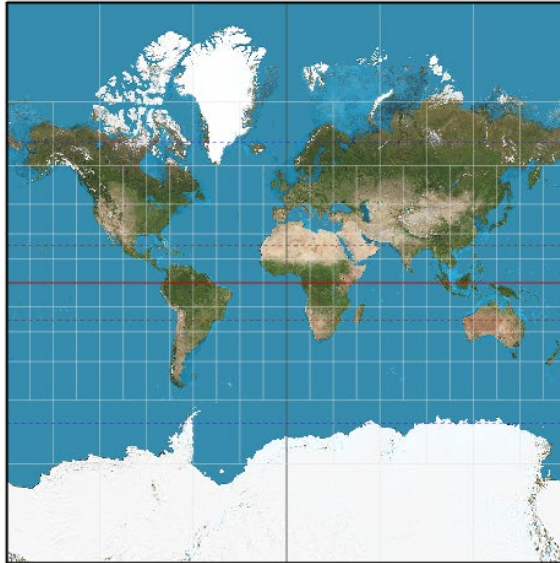
Educational challenge: Teaching about distortion

Competing ideas on how and what to teach about distortion
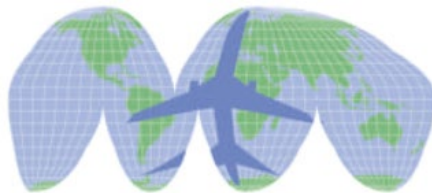

Near-side general perspective

Wikipedia
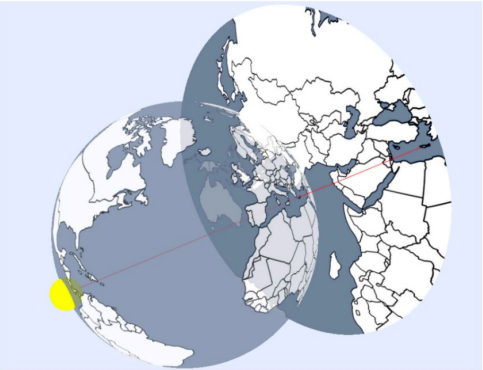
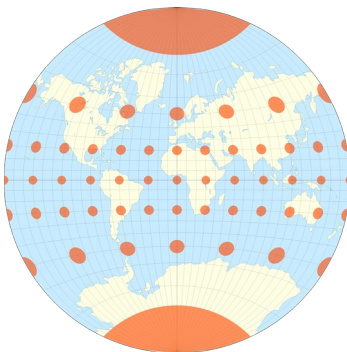

Heitzler, et al. (2019)

Olson (2006).
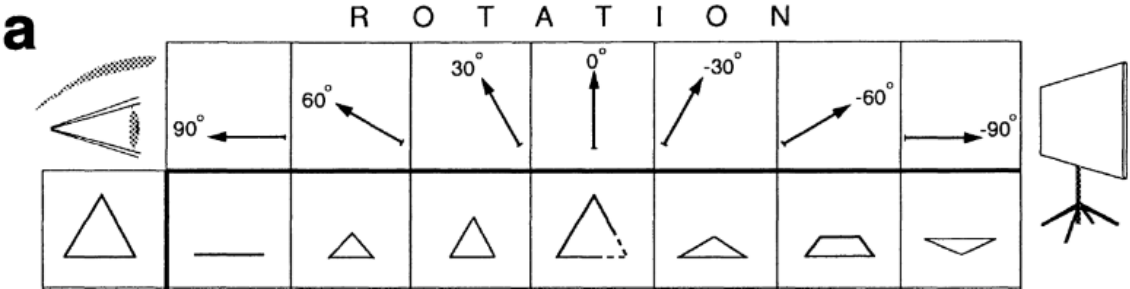
Downs & Liben (1991)

Educational challenges: Teaching about distortion

We know a lot about proportional circles, but very little about the understanding and utility of distortion symbolization
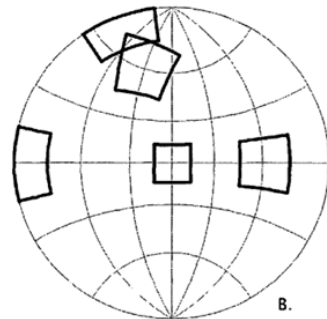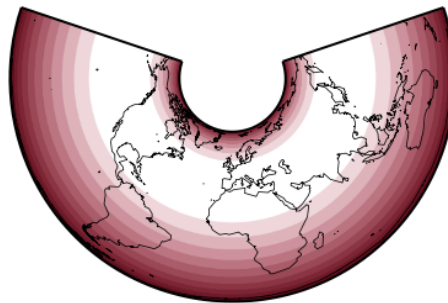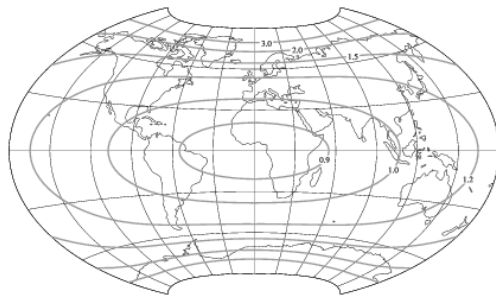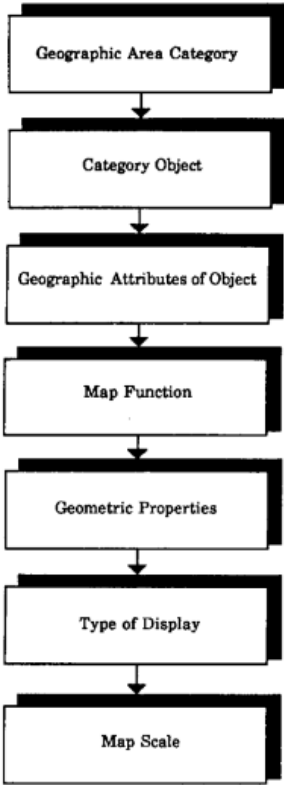

Mulcahy & Clarke (2001)
Field (2019)
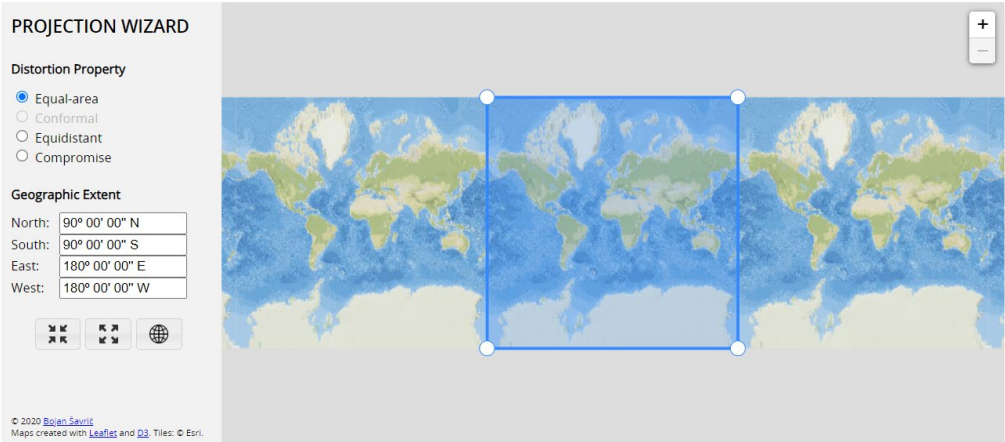Reeves (1910)

Selecting Projections: A top-down approach

Eldrandaly (2006)

Šavrič et al. (2016)

Jankowski & Nyerges (1989)
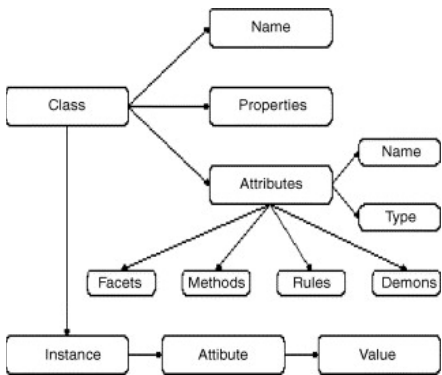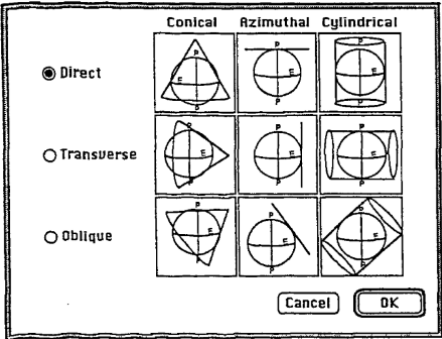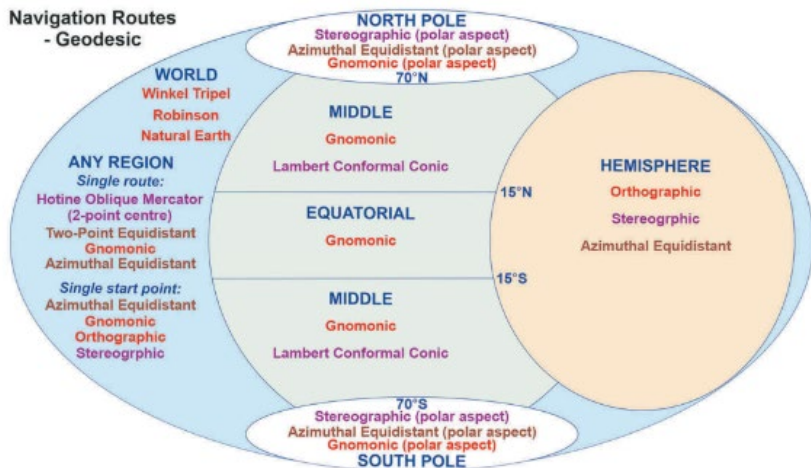
De Genst & Canters (1996)
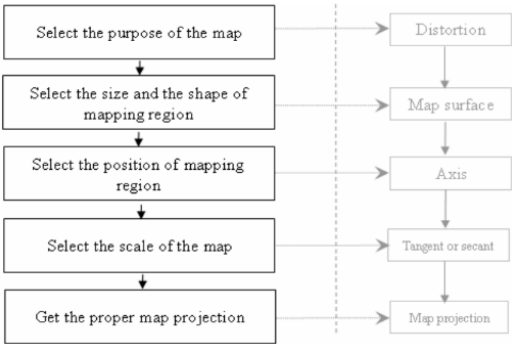
Zhao, Hu, et al. (2007)

Selecting projections: More bottom-up?

"No single existing solution fully incorporates both key selection elements of [map] purpose and geographic footprint characteristics, whilst also including methods for distortion reduction and visualization." (p.263)

Gosling and Symeonakis (2020)

- Who is the audience for the guidelines?
- Does one "size" guideline fit all?
- How helpful are guidelines?
  - do end users know what a projection's property is required?
  - terminology issues
  - do people use exiting guidelines?
- Implementation issues (paper vs. digital)

Experts ⟹ Everyone Else
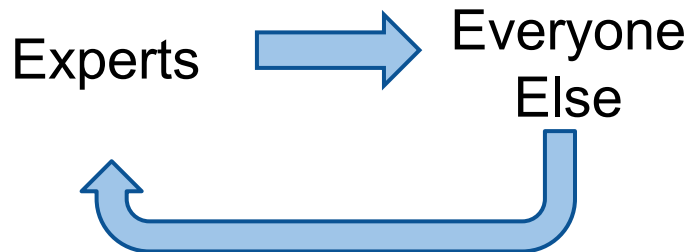
What are the Big Takeaways?

- Distortion in map projections makes both research & analysis challenging

- Notable disconnect between what we "know" about projections and how we perceive data / analysis in projected space

- More research is needed on how and what to teach map projections

- Education outreach beyond formal school settings is similarly uncharted landscape

- Map projection selection guidelines are potentially useful, but more thought needs to focus on the end user's requirements

Thank you for your attention!

Questions?