Data Visualization (CSCI 627/490)

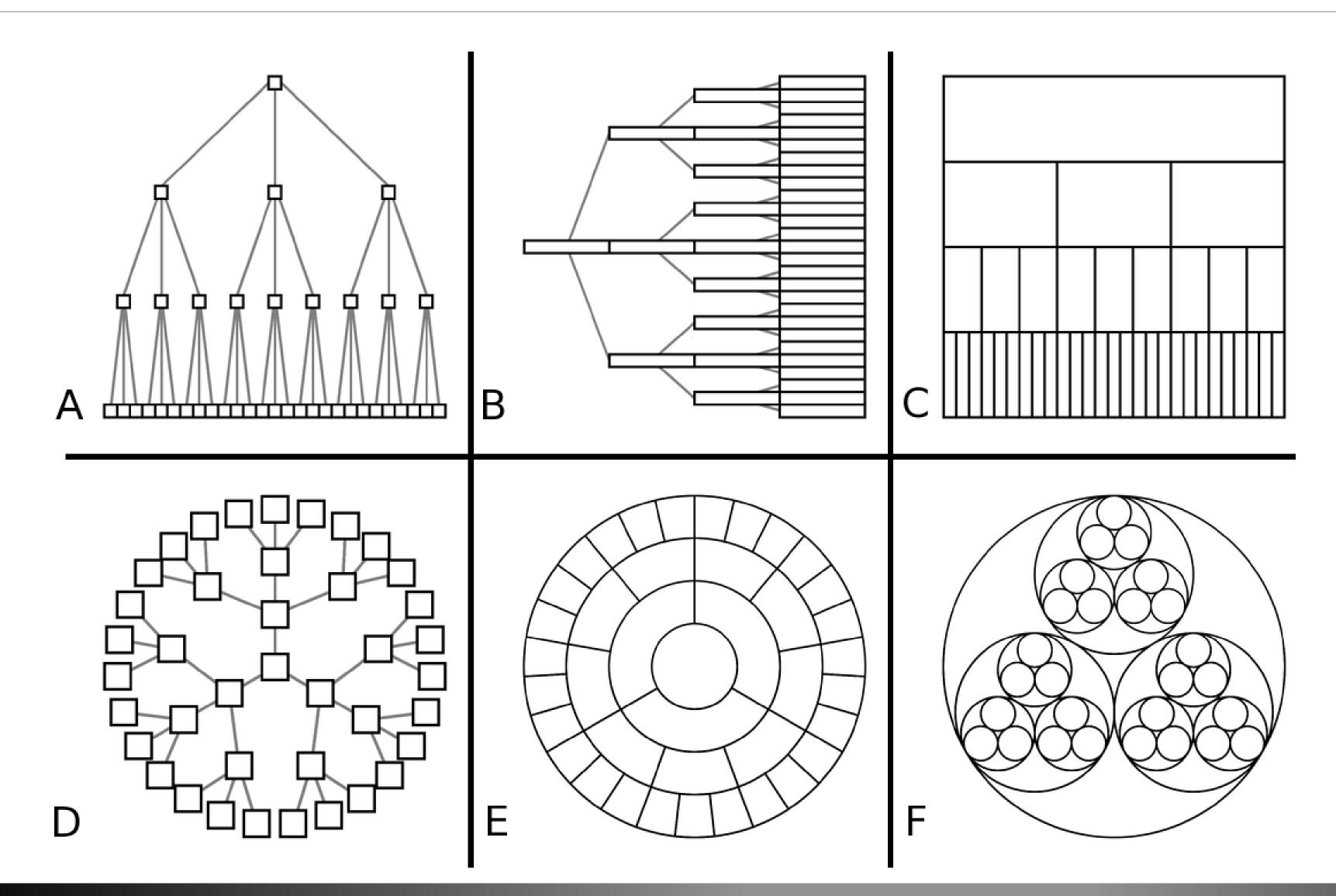
Design & Interaction

Dr. David Koop

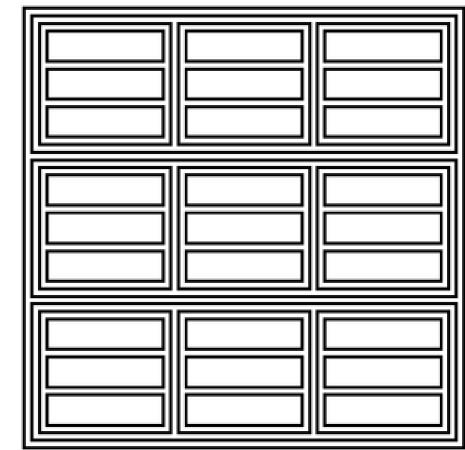


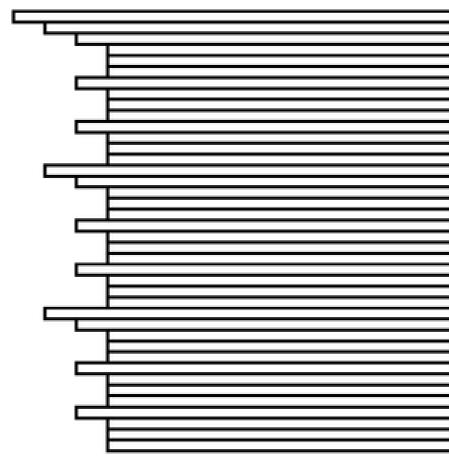


Tree Visualizations



D. Koop, CSCI 627/490, Fall 2020





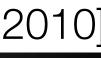




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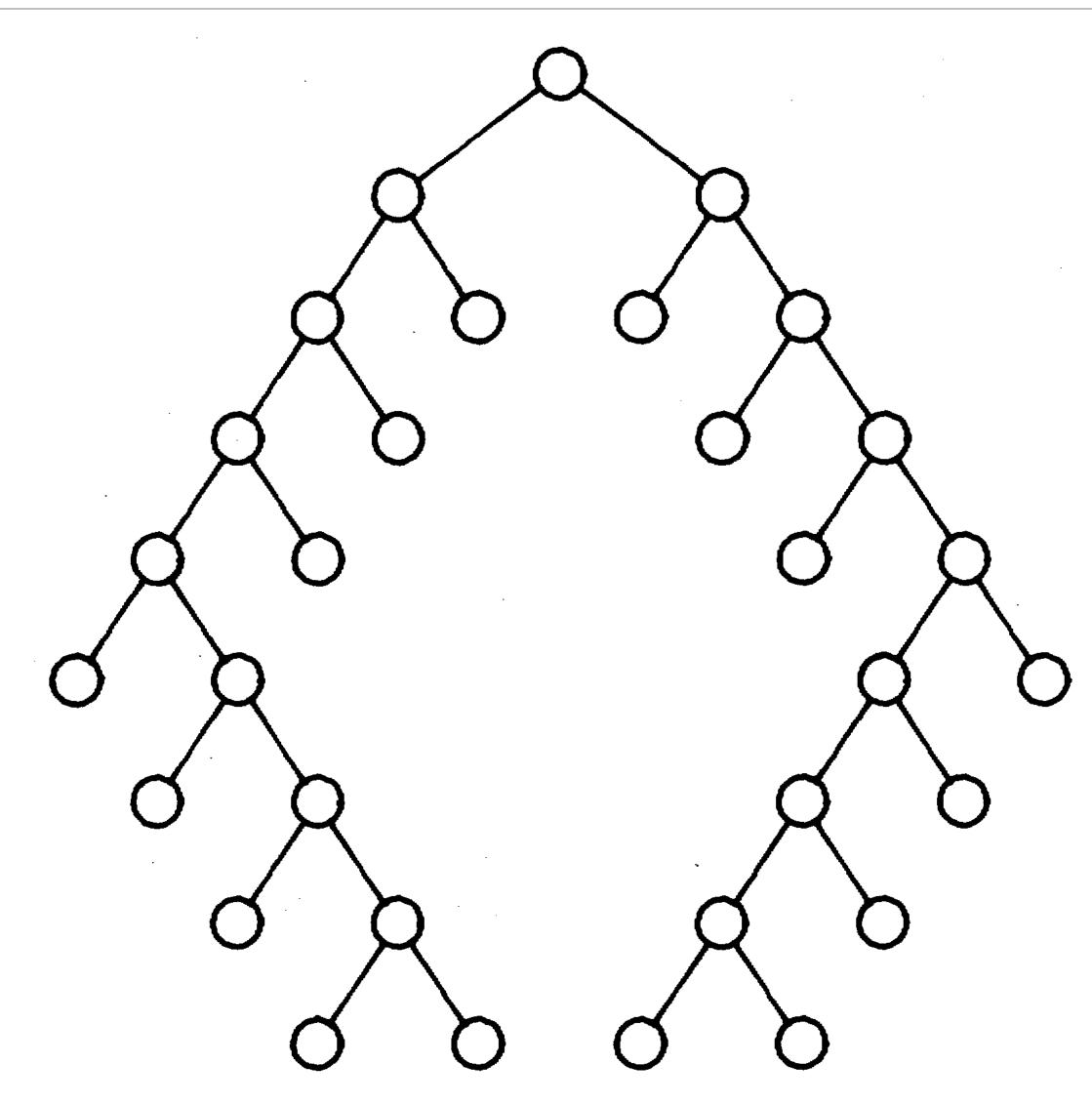






2

Reingold-Tilford Algorithm



- Recurse on left and right subtrees
- Shift subtree over as long as it doesn't overlap
- Place parent centered above the subtrees
- Originally, only binary trees, extended by Walker















Ireemap

				IUGKS	, vans	5, 5.0. 9. 5	CANSP	
	Dodge Ram 364,177	Chrysler Town & Country 159,105	Chrysler PT C 138,650	ruiser	liberty 57	Chrysler 30 143,647	30	
				Charact		0.44	Dodge Charger	Dodge Caliber
	Dodge Caravan		Jeep Cemmandar 88,497	Chrysl Pacific 78,243	a	Dodgo Dakota 76,098	114,201	92,224
l		Jeep Grand Cherokee 139,148		Dodge	D	odge		
	211,140		Jeep Wrangler 80,271	Durani 70,606	30 M	agnum 0,095	Chrysler Sebring 69,357	Dodge Stratus 51,993

TRUCKS VANS S.U.V.'S | CARS

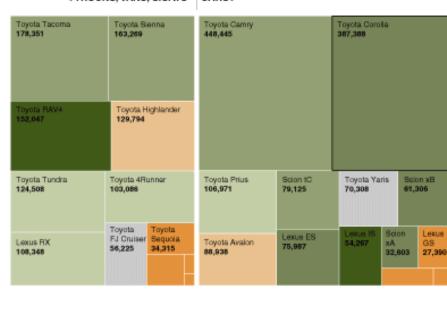
Chevrolet Silverado 636,069	,			C Sierra 1,736	Chevrolet is 289,868	npala			ntole ,449	t Cobalt		
Chevrolet Trai Blazer 174,797	Chevrolet Equinox 113,668	Chowrok HHR 101,298		Chevrolet Colorado 13,876	Chovrolet N 163,853	Aalibu		Pontiac G8 157,644				
Chevrolet Tahoe 161,491			Chevrole Uplander 58,699	Avalanche 57,076	Pontiac Grand Prix 108,634		atum lo 12,042	n	Lu	iok cerne ,615		
	Chevrolet Suburban 77,211	Hummer H3 54,052	Toment 43,174	Cadillac Escalade 39,017	Buick LaCrosse 71,072	Cadila DTS 58,224	M	ontiac be 5,221		Chevrolet Convette 36,518		
Chavrolat Express 123,195	GMC Envoy 74,452	Buick Pandazyous 45,954 GMC Yukon XL 45,413			Chevrolet Aveo 58,244	Cadila CTS 54,846	C 34	ionte arlo 4,113	Saa 9-3 24,1			

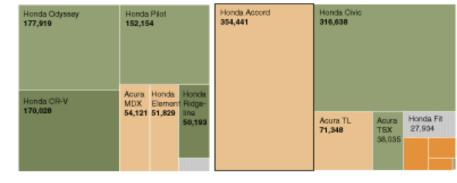
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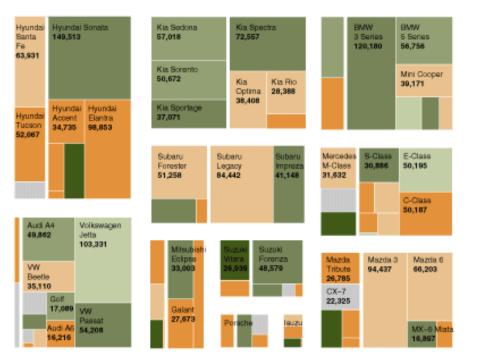
 Mercury
 Victoria
 Town Car
 Aud A6
 54,208

 29,567
 57
 19,296
 19,296
 Porsche





Nissan Murano 81,362	Nissan Pathfinder 73,124	Nissa 72,19	in Titan 12	Nissan Altima 232,457	Nissan Sentra 117,922	
Nissan Frontier 77,510	Nissan Xlarra 82,325	Nissan Armada 32,864	Nissan Quest 31,905	Nissan Maxima 69,763	Infiniti G35/45	
		Infiniti FX 22,656				



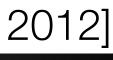
- Encodes some quantitative attribute of the items as the **size** of the rectangles
- Not as easy to see the intermediate rectangles (hierarchy)
- Scalability: millions of leaf nodes and links possible

D. Koop, CSCI 627/490, Fall 2020

 Containment marks instead of connection marks—show hierarchy

[A. Cox and H. Fairfield, <u>NYTimes</u>, 2012]





Treemap Layouts: Slice & Dice

- Split at each level into strips
- At each step, orientation of division (horizontal/vertical) changes
- Better, but some rectangles still have bad aspect ratio

D. Koop, CSCI 627/490, Fall 2020

Node Link Tree Layout				Labeler 9,956	Prope Encod 4,138	Distor 6,314	Fishe Tree Filter 5,219	O C (Li S { 5, 4 2		oGtrings 如楚寒,朝楚母r 1,02236	Interpo N C F / F C I 8,746 Ir Ir II II II II 2 2 1	radigtedbioplicultudi 77663689936668916848	Misel I FLPD(M 555 Ci	Time Scale	Gr <u>I</u> Cc <u>0</u> 9,8 (22	190 0 D Body O Force 1,10,49	Te Sp t¢0
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Circle Layout 9,317 Tree Map						Bifoca Distor	Visib Filter			19,118		Query 13,896		Quan Scale			
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Force Directed Layout Layout				Radial Labeler 3,899	3,179					Maths 17,705	13,373						
7,881 Axis Layout				Ştacked		Fishey Distor 3,444	Grap Dista Filter 3,168					Expression 5,130		Scale			
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										10,993		Arithmetic 3,891 Match	Hie A C Clu C S 6,7 ⁻ 3, 3	Merge Edge			
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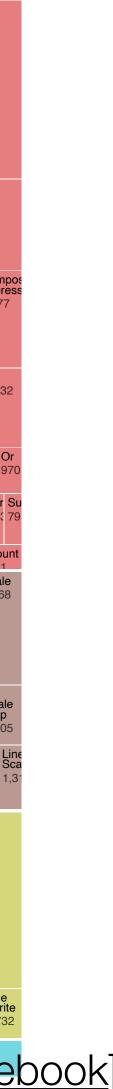


Treemap Layouts: Squarify

- Slice & Dice and Strip can lead to bad aspect ratios
- Solution: Strip only uses rows, allow columns to be used, too
- Choose divisions (x/y) based on the width/height of region in order to maintain good aspect ratios
 - Use left and right side
 - Process large rectangles first
- Ordering not preserved which may cause issues if the data is updated

Node Link Tree Layout 12,870		Circle Layou 9,317		Circle Layout 9,317		Layout Map		Layout		Map A Layout La		p Ai /out La		Map A Layout La		Map A Layout La		Map Ar Layout La		vlap Ar ₋ayout La		Map Ar Layout La		Map A Layout La		Map A Layout L		Map Ar Layout La		Map Are Layout Lay		Map Are Layout Lay		Map Are Layout La		Map A Layout La		Map A Layout La		Map Ar Layout La		tacked rea ayout ,121				Data List 19,78			Interpolator 8,746 Matrix Color R	19	ansitior ,975	ner	gt mu 60(60 div ed	48 628 619 sul ne lt 600 59 59	13,896	
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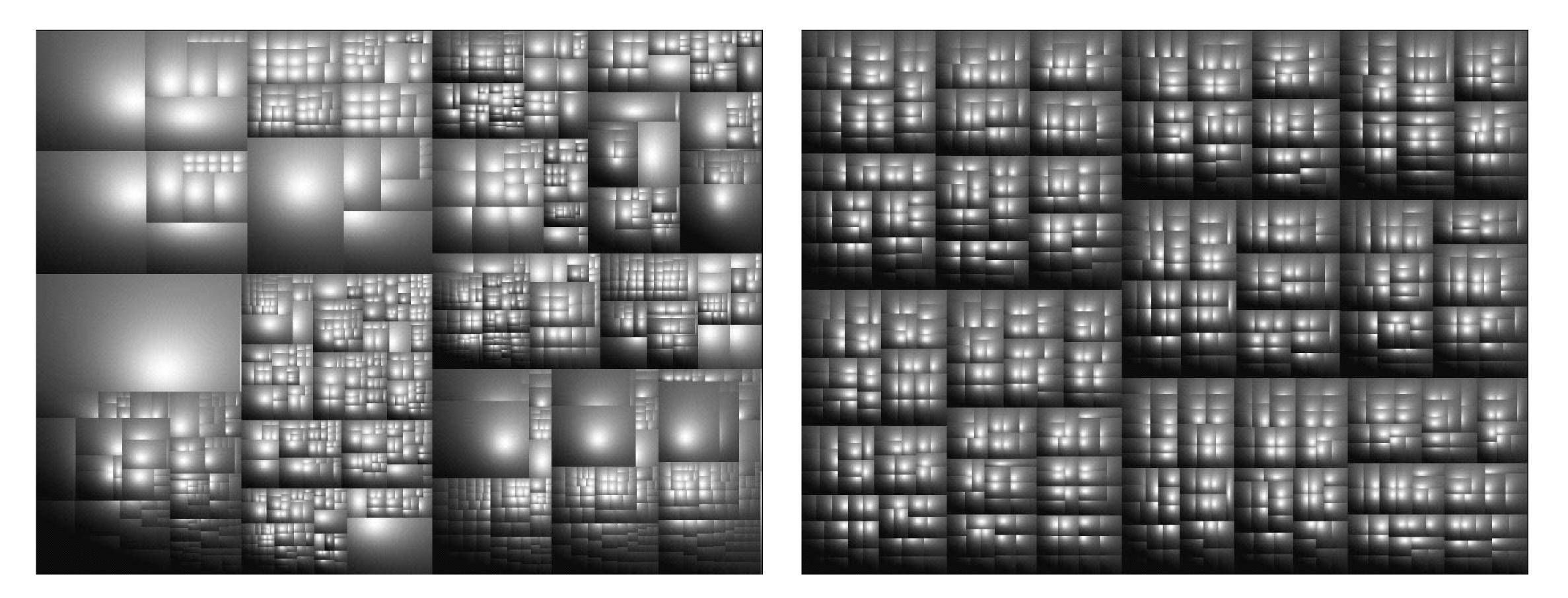








Squarified + Cushioned Treemaps

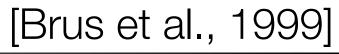


(a) File system

D. Koop, CSCI 627/490, Fall 2020

(b) Organization

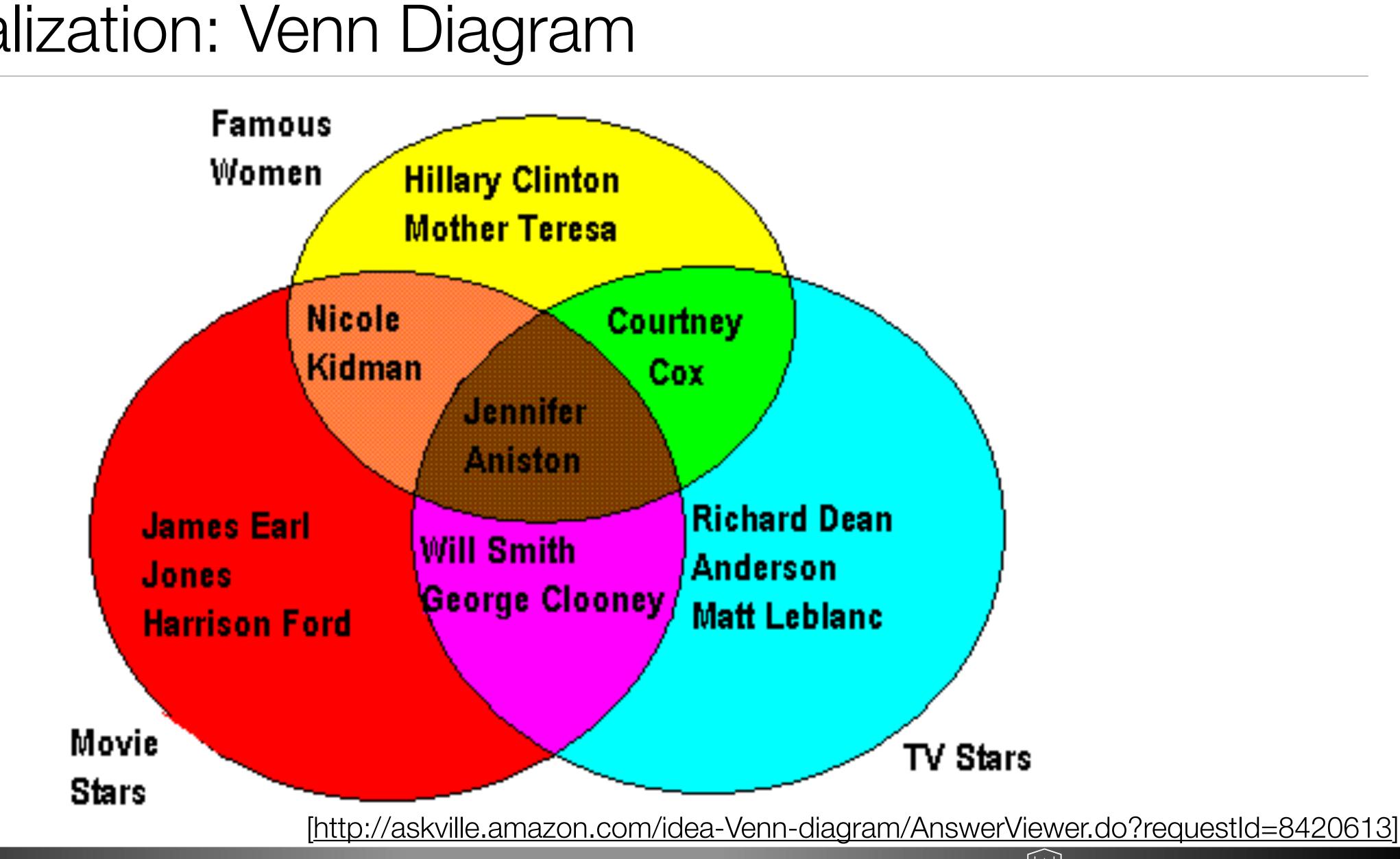








Set Visualization: Venn Diagram





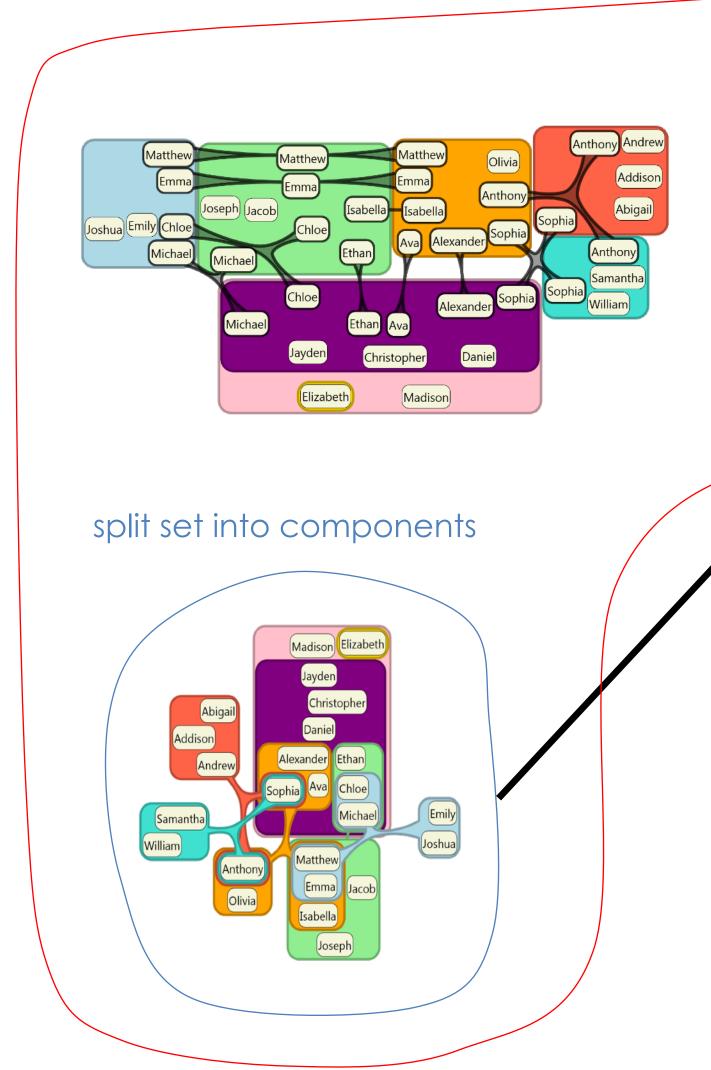




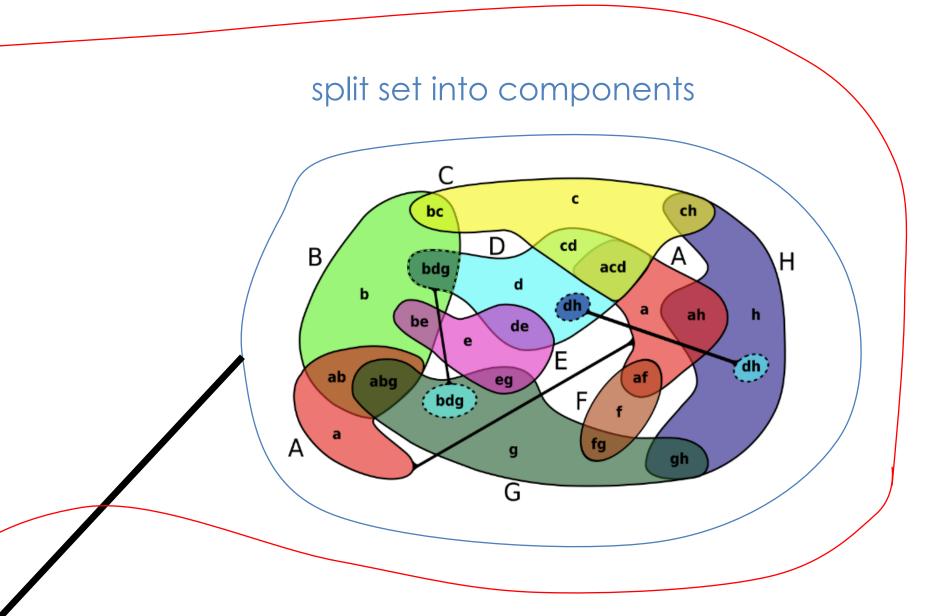


Euler Diagram Variants

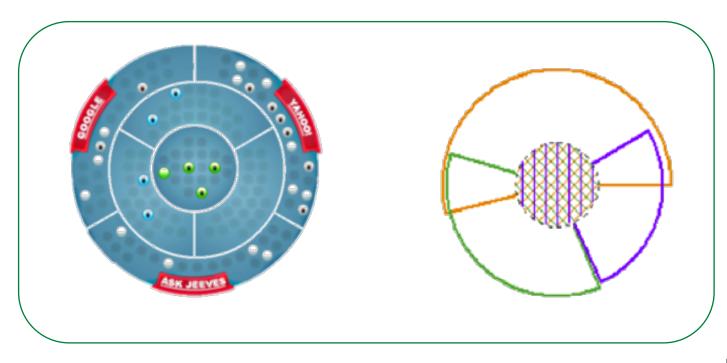
use edges



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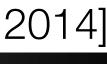


use a concentric layout





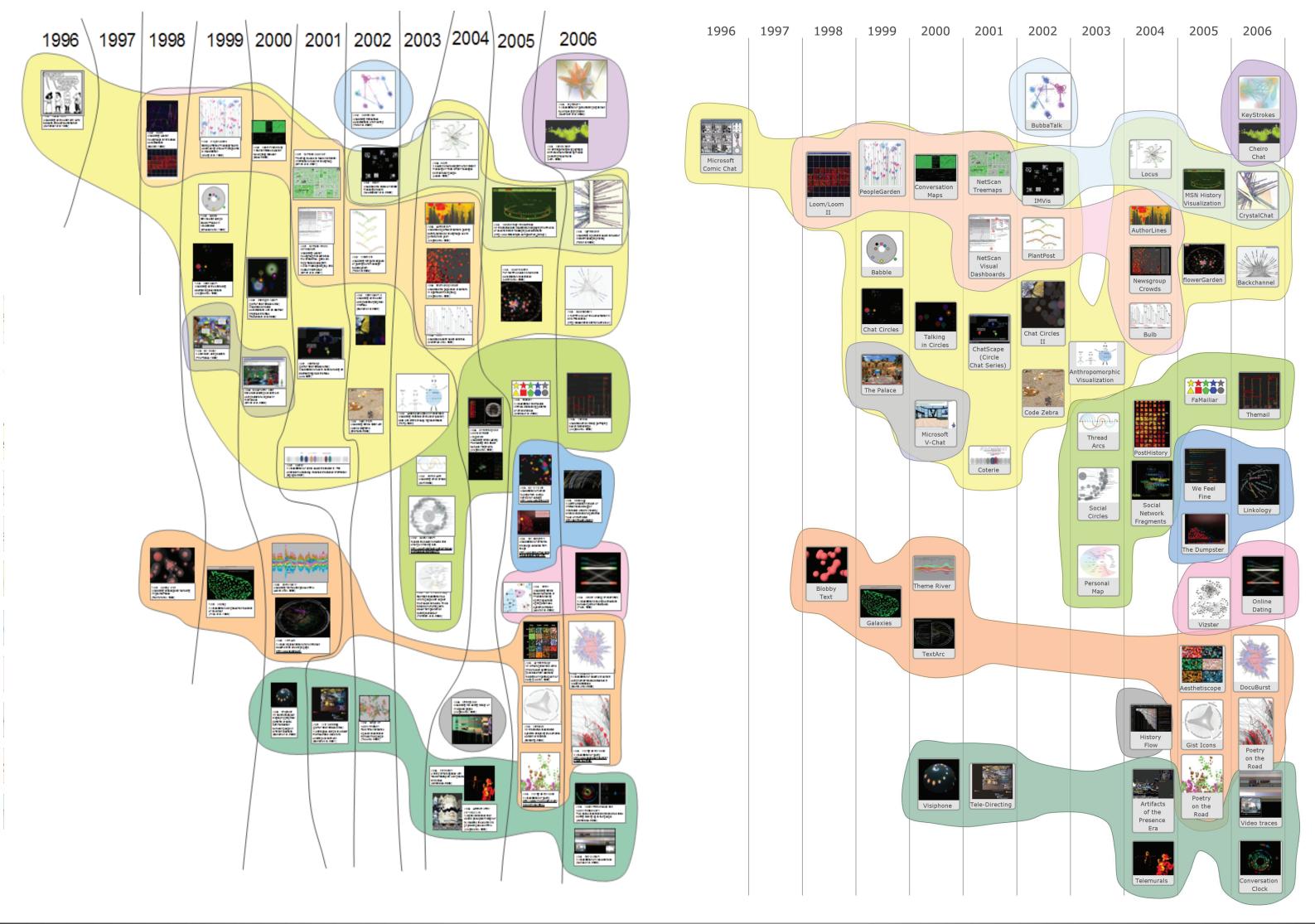








Bubble Sets: Overlay set membership



D. Koop, CSCI 627/490, Fall 2020



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Bubble Sets & Overlay Techniques

- Given spatial layout is determined by other attributes, want to show set containment without modifying spatial layout
- Idea of "spatial rights"
- Construct regions based on a potential field
- Draw using containment marks
- How do we compute these?





Bubble Sets & Overlay Techniques

- Given spatial layout is determined by other attributes, want to show set containment without modifying spatial layout
- Idea of "spatial rights"
- Construct regions based on a potential field
- Draw using containment marks
- How do we compute these?
 - Marching Squares!





KelpFusion



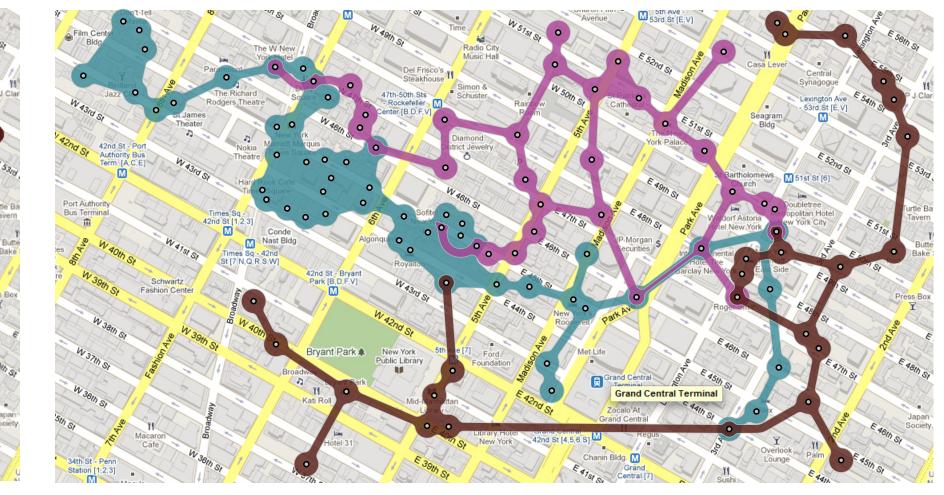
(a) Bubble Sets



(b) Kelp Diagrams

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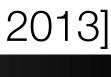
(c) LineSets



(e) KelpFusion (medium)



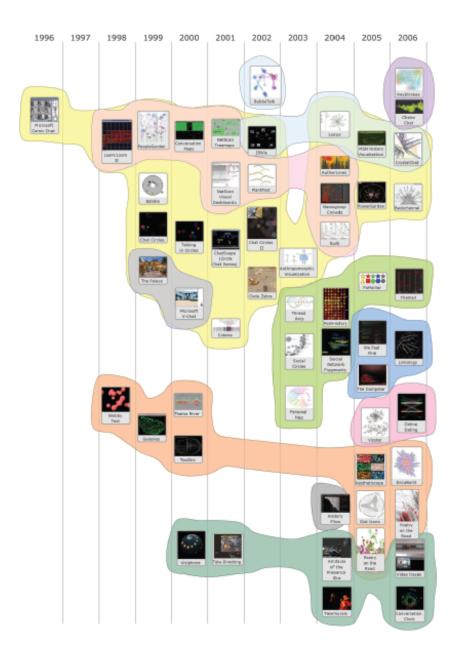
[Meulemans et al., 2013]



12

Overlays

Region-based





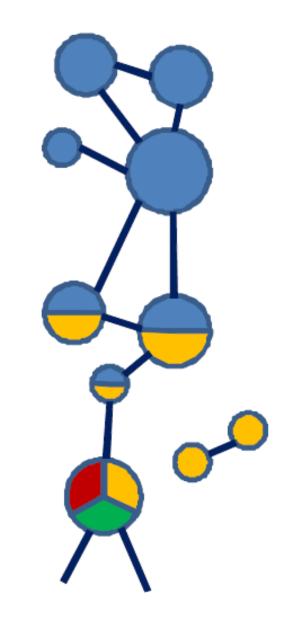
[Collins et al., 2009]

D. Koop, CSCI 627/490, Fall 2020

Line-based

[Dinkla et al., 2012]

Glyph-based



[Itoh et al., 2009]

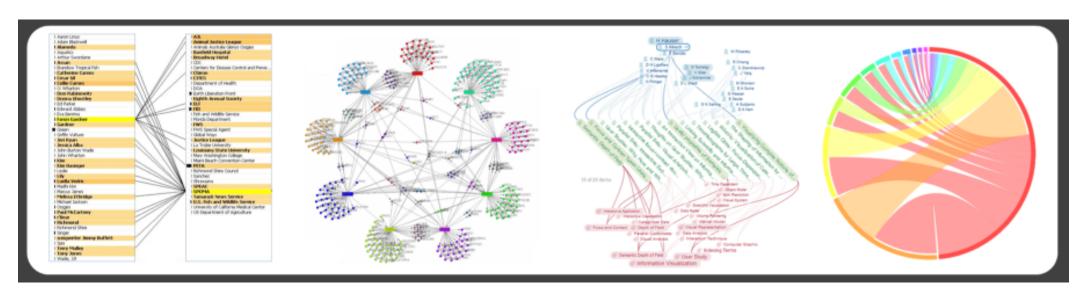




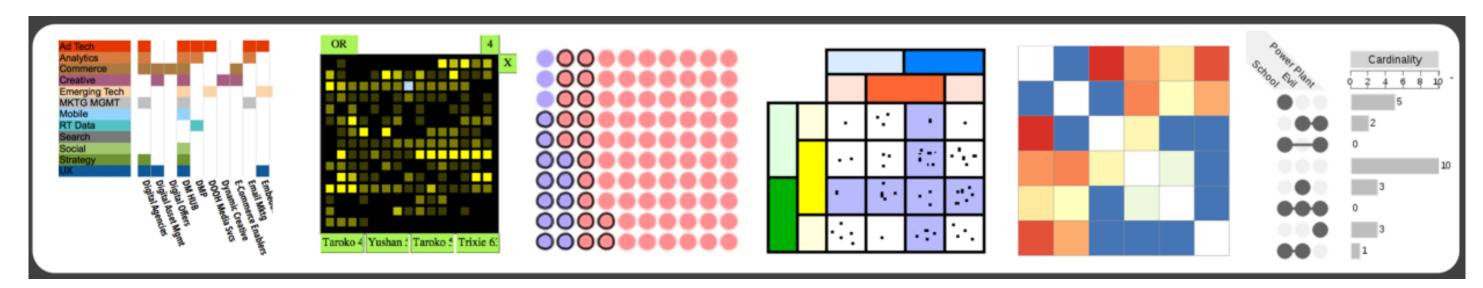


More...

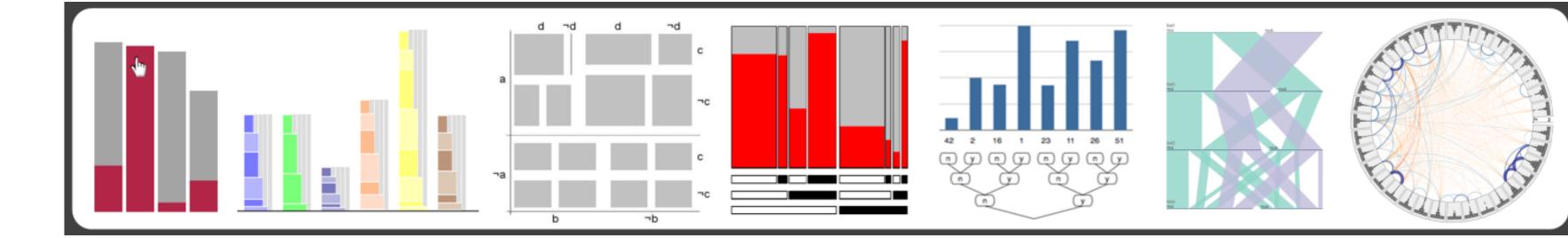
Node-Link Visualizations



Matrix-based techniques



Aggregation-based techniques



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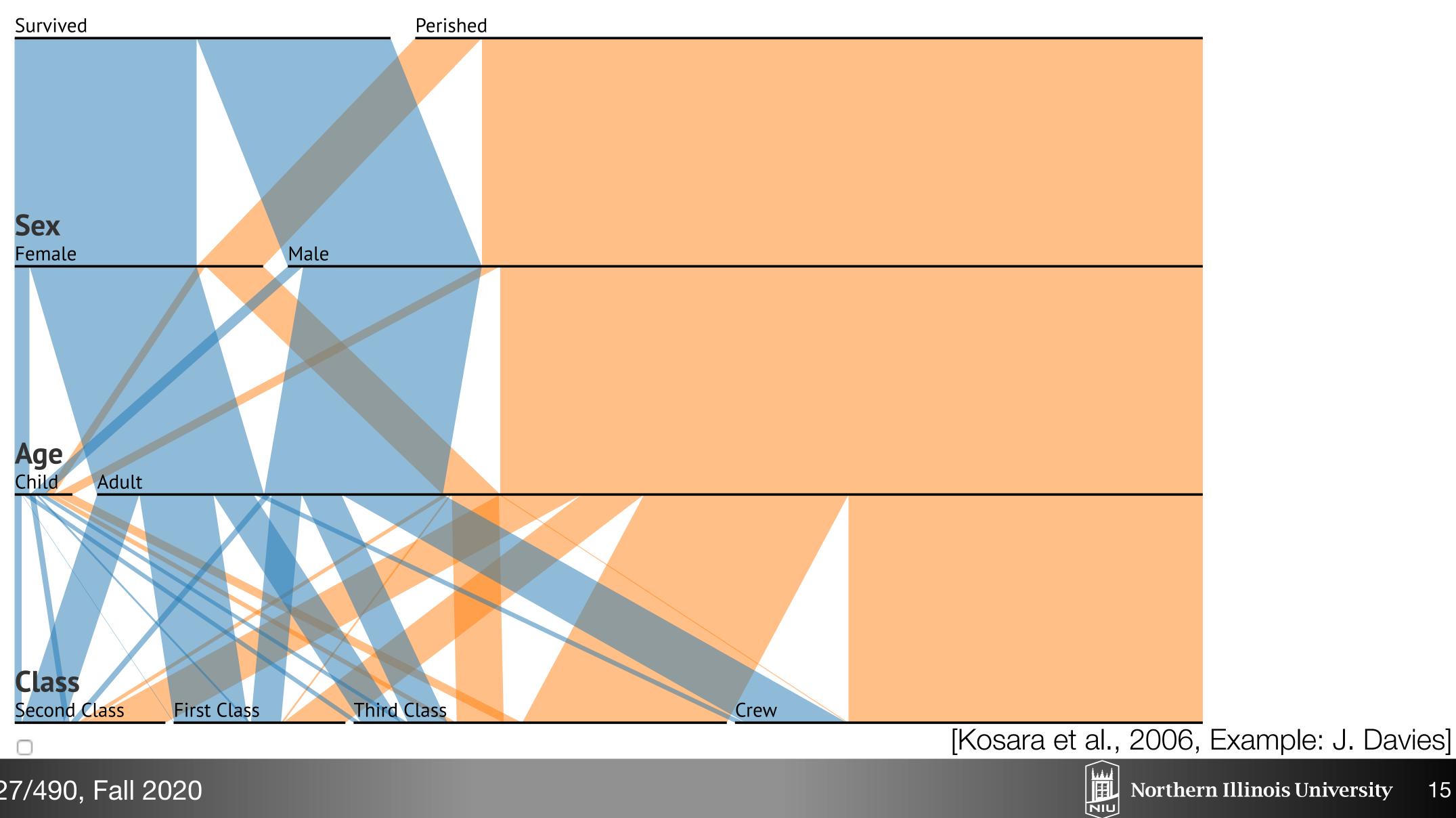


[via B. Alsallakh et al., 2014]

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More... Parallel Sets



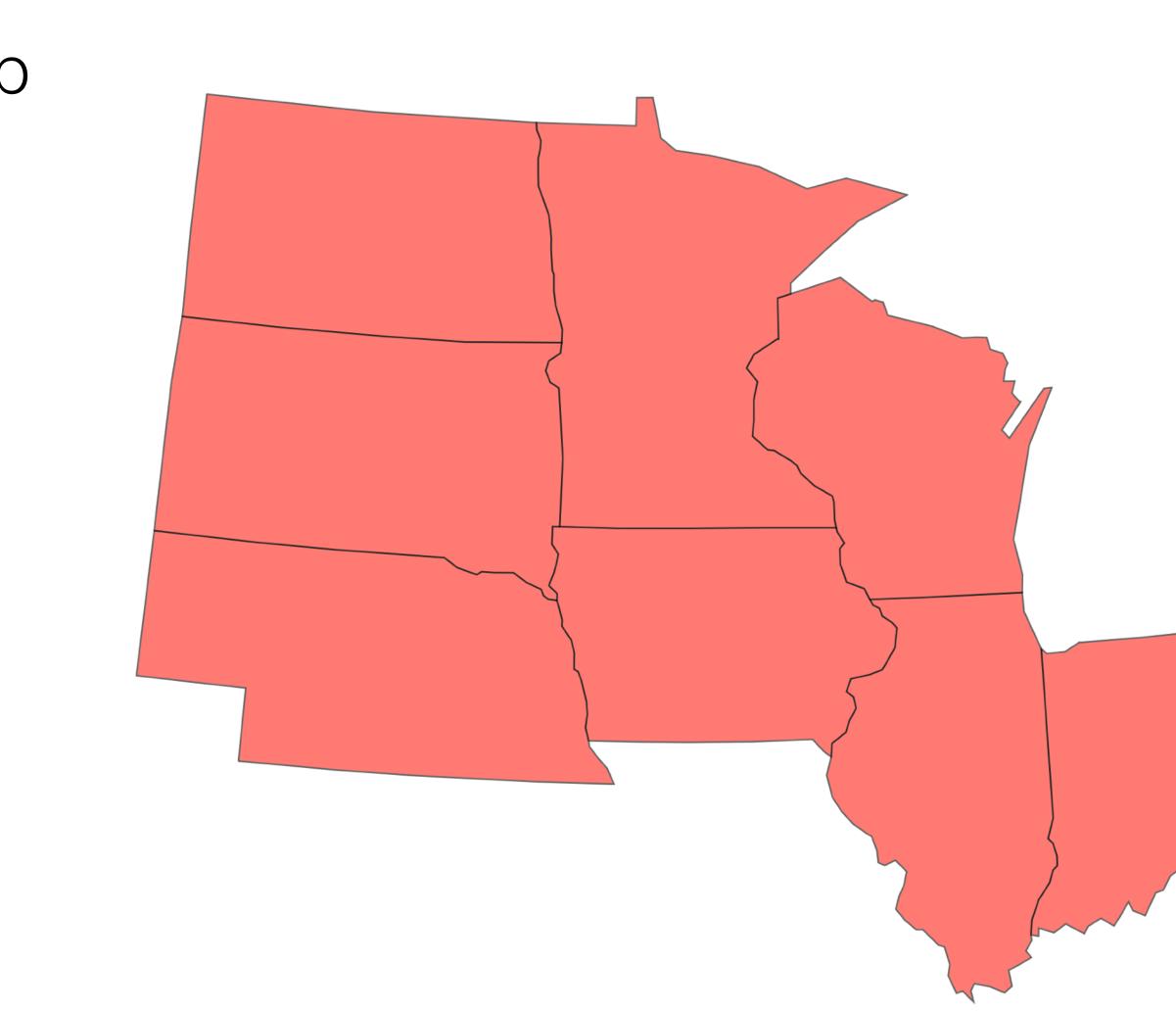
D. Koop, CSCI 627/490, Fall 2020



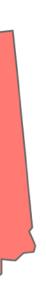
15

Assignment 4

- Geospatial Visualizations & Treemap
 - Choose colormaps carefully
 - Add legend











Project Design

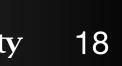
- Start working on turning your visualization ideas into designs
- Feedback to Blackboard soon
- Sketch (talk about today)
- Options:
 - Try vastly different options
 - Refine an initial idea





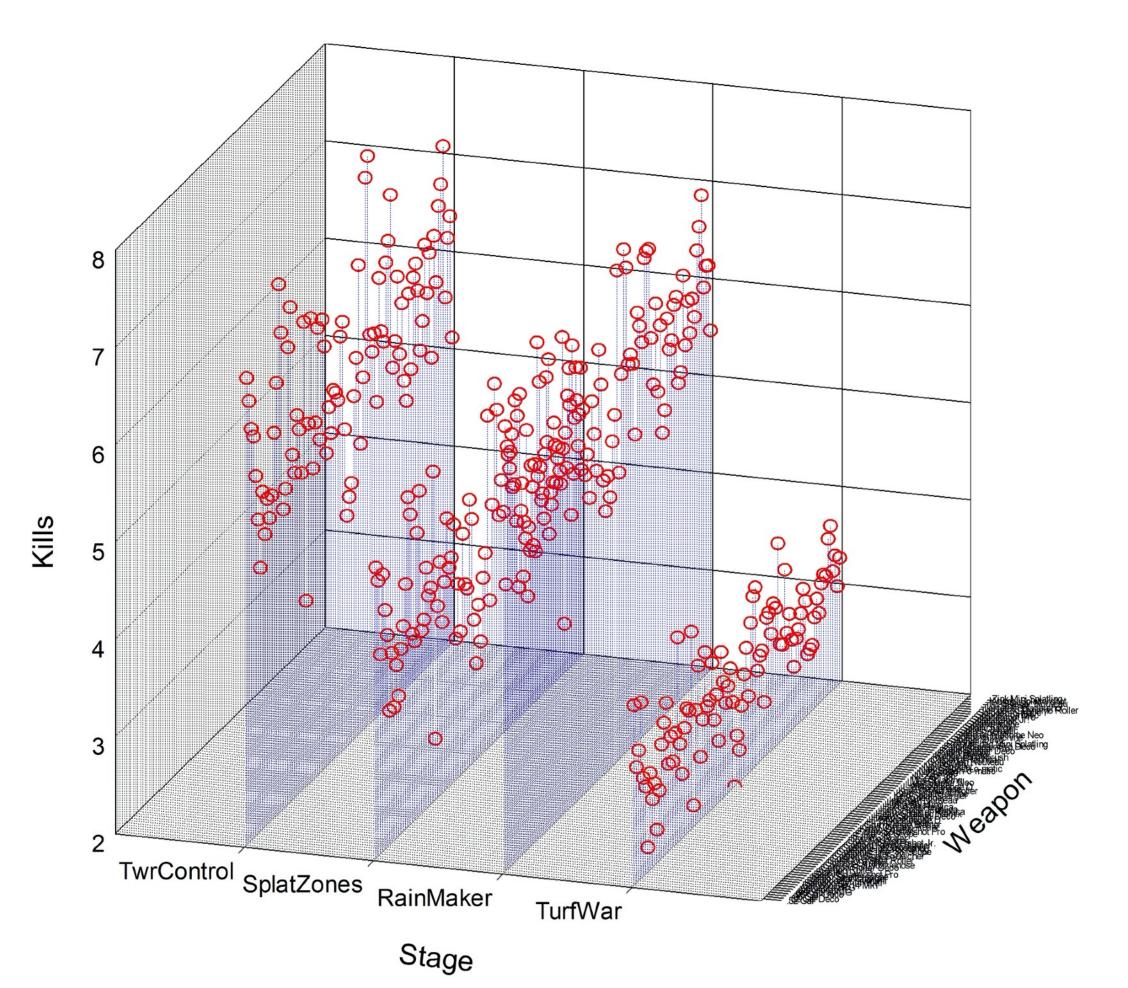
Guidelines for Visualization Design



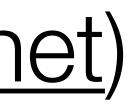


WTF Visualizations (<u>wtfviz.net</u>)

3D Category Scatter



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19

Tufte: "The da Vinci of Data" —<u>NYTimes</u>



D. Koop, CSCI 627/490, Fall 2020

BEAUTIFUL EVIDENCE

The Visual Display of Quantitative Information SECOND EDITION

VISUAL EXPLANATIONS

[https://www.edwardtufte.com/tufte/, 2017]



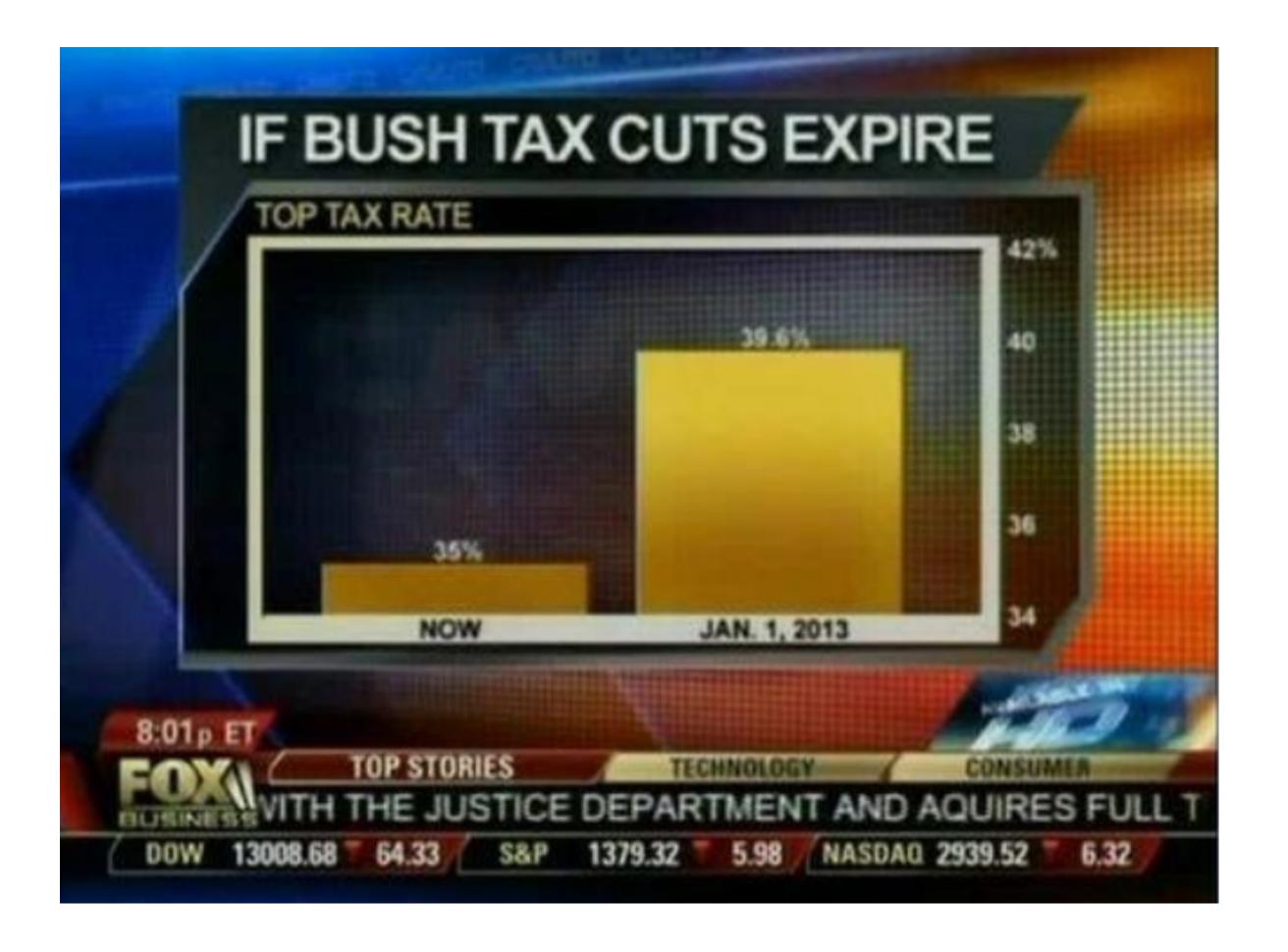
Northern Illinois University







Bad: Data magnitude $\langle \neq \rangle$ Mark magnitude



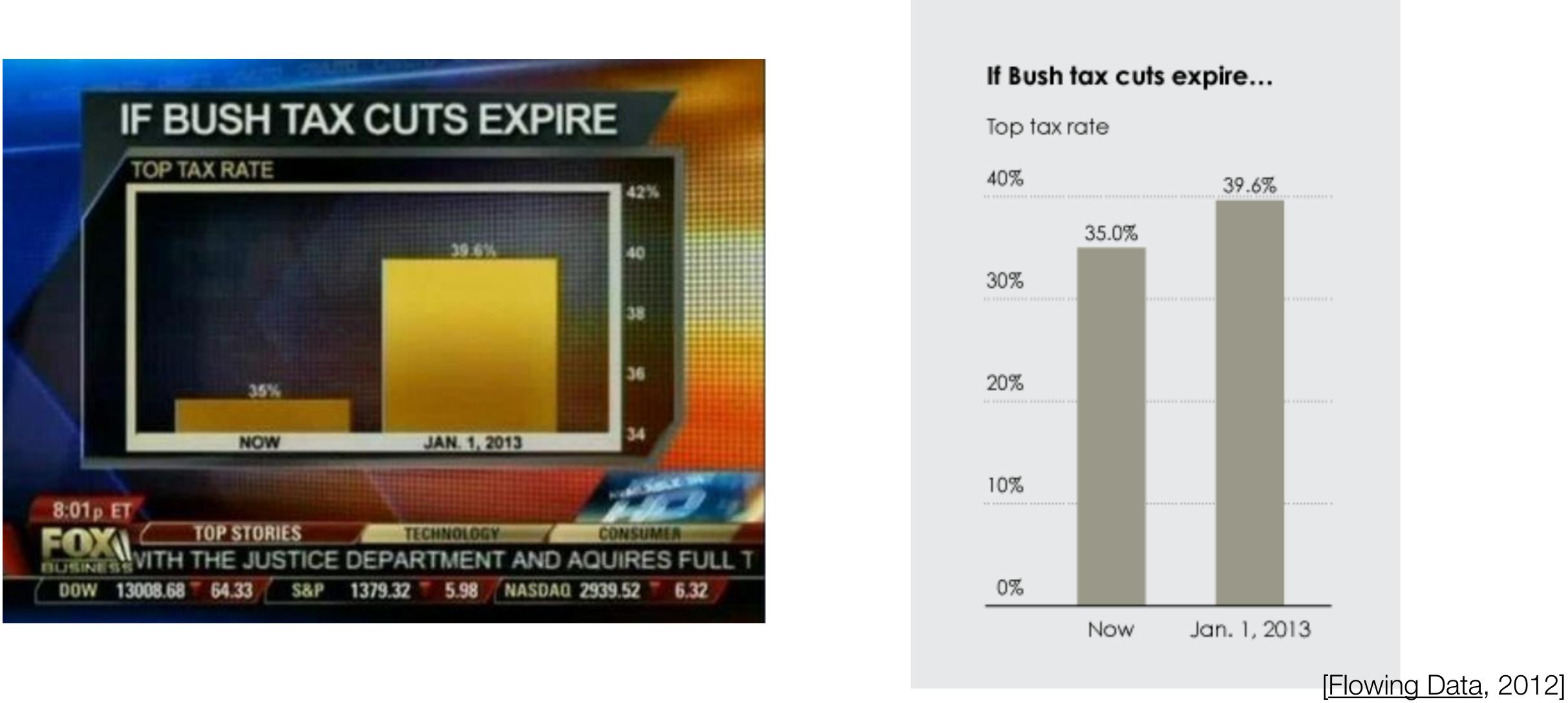




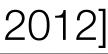




Good: Data magnitude <=> Mark magnitude



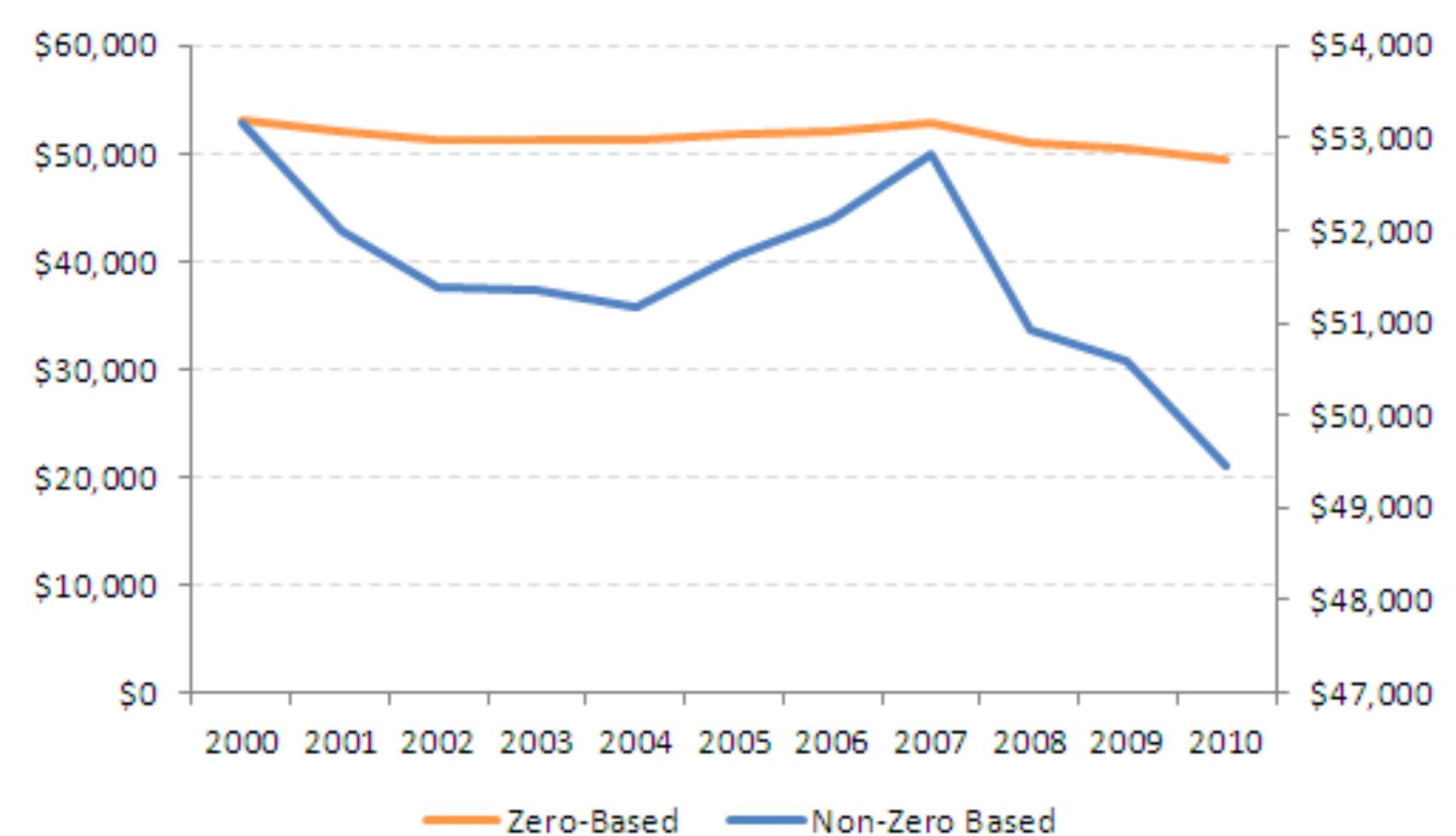






Starting Scales at Zero?

Median household income in 2010 inflation adjusted dollars



D. Koop, CSCI 627/490, Fall 2020

——Non-Zero Based



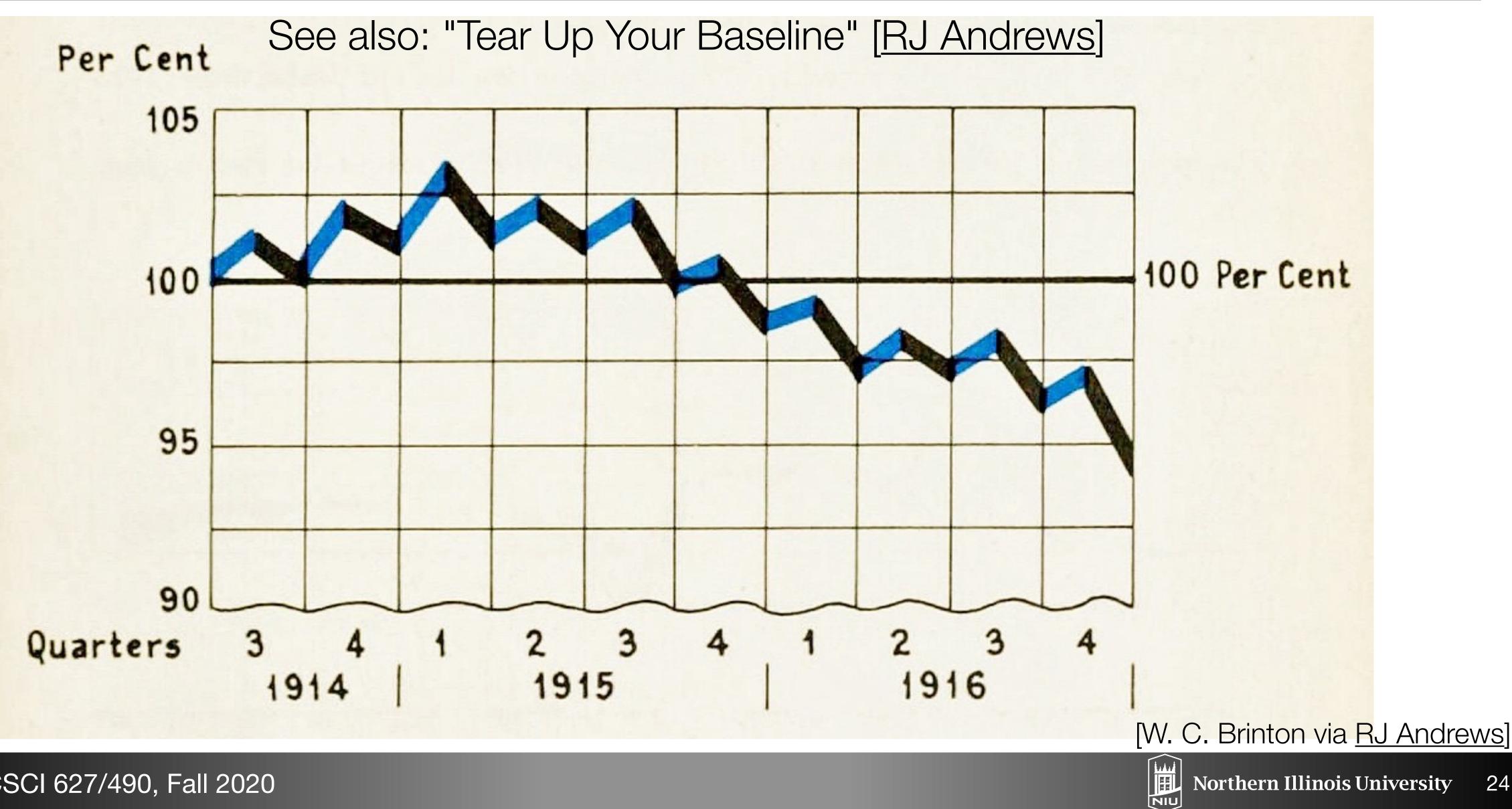








Wavy baselines for non-zero starts

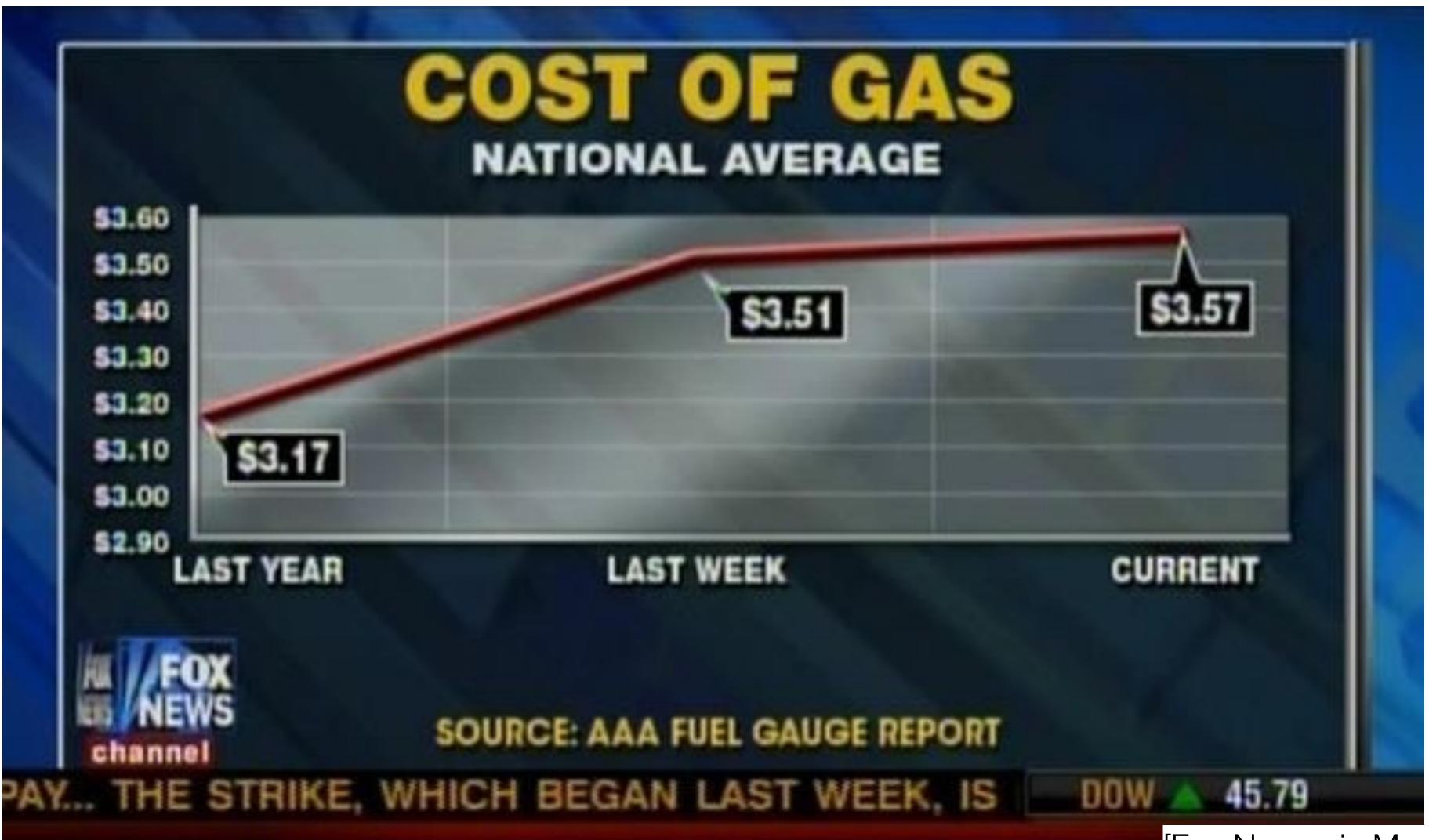








Cherry-picking data



D. Koop, CSCI 627/490, Fall 2020

[Fox News via Media Matters, 2012]

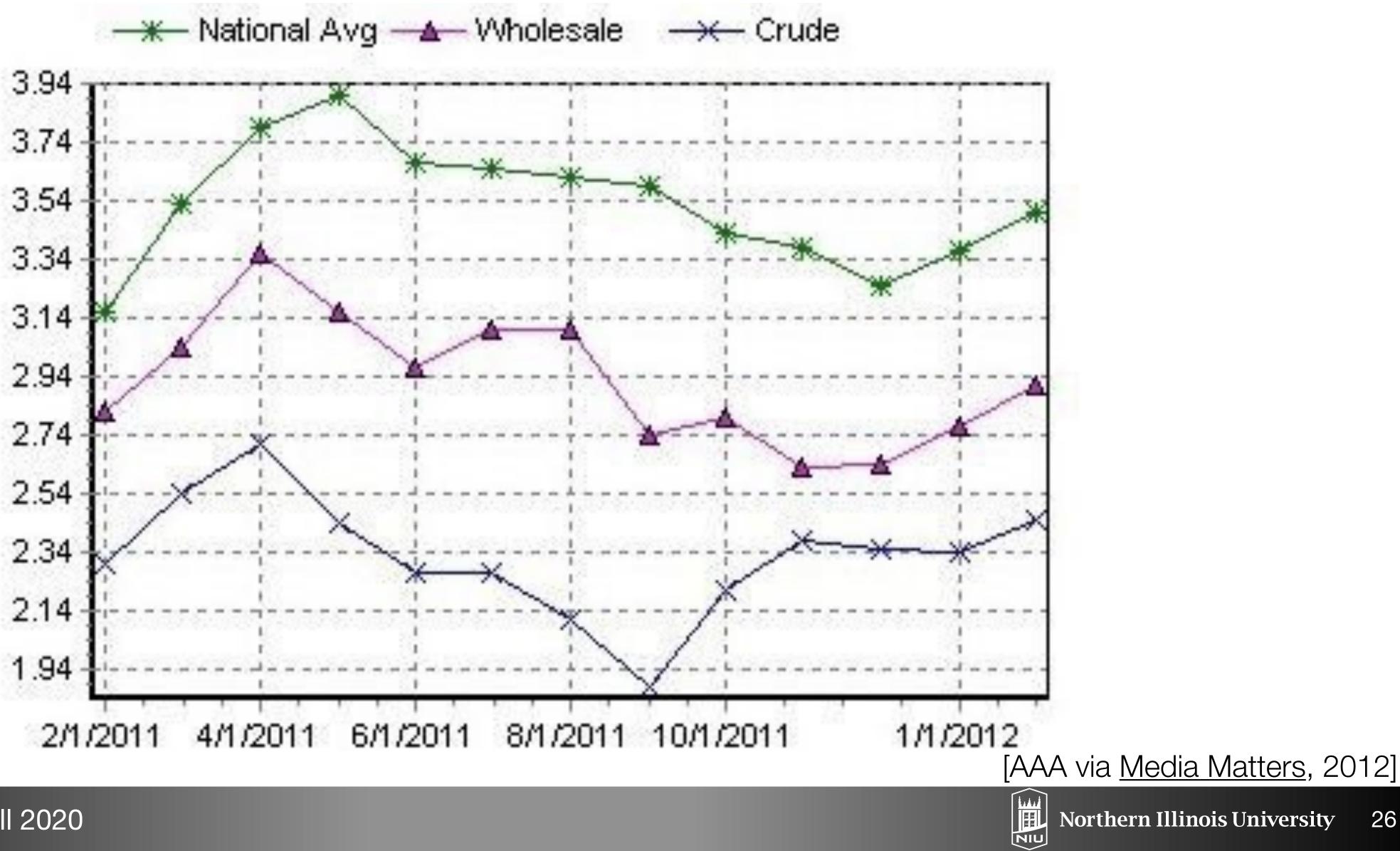








Show all the data

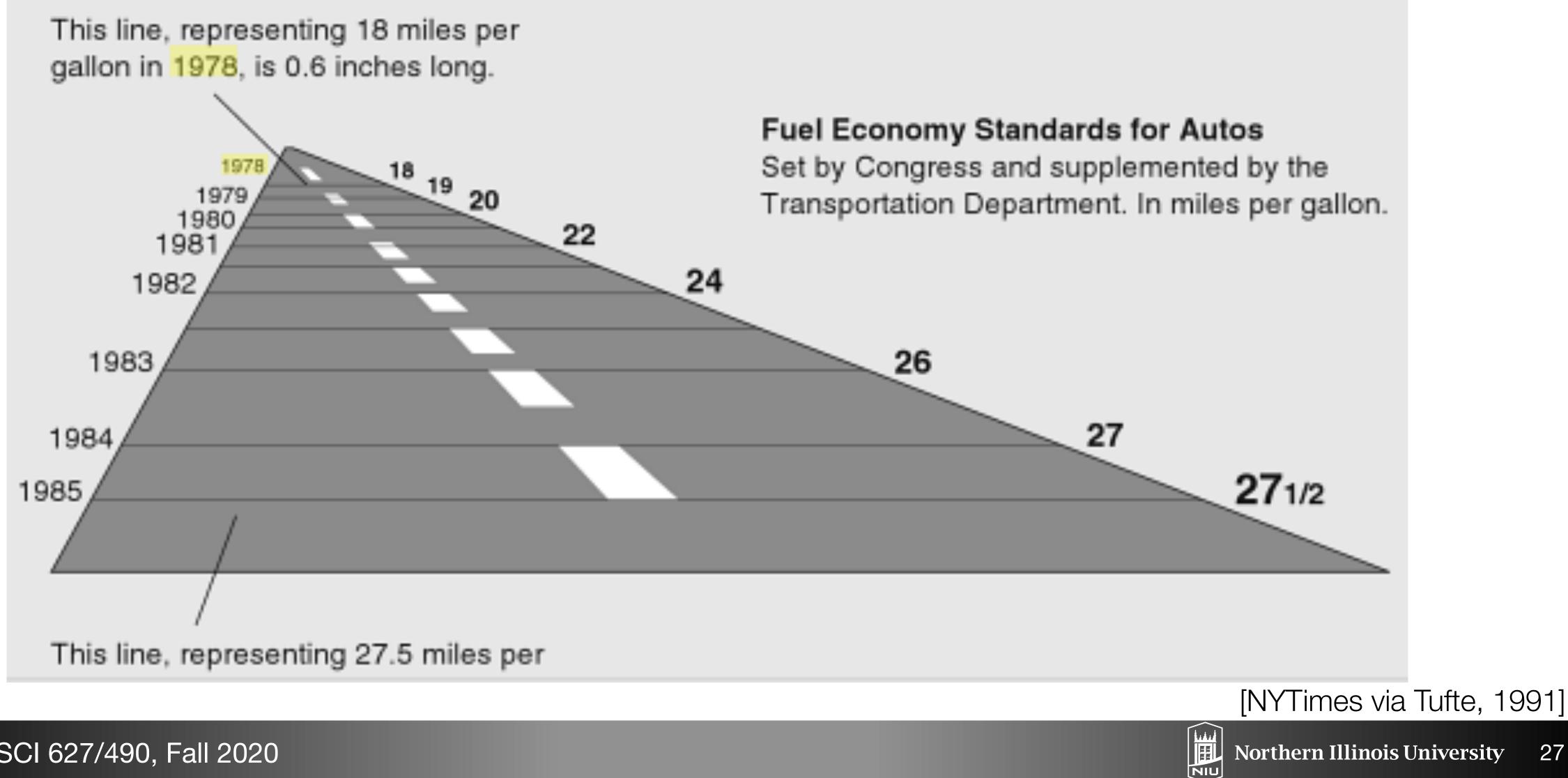








Tufte's Lie Factor



D. Koop, CSCI 627/490, Fall 2020



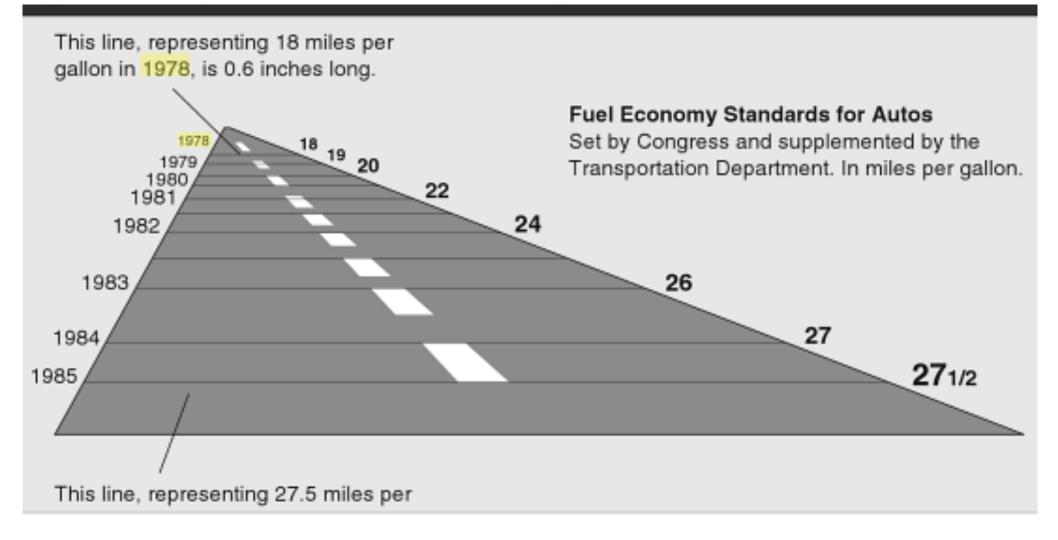
27

Tufte's Lie Factor

- Size of effect = (2nd value 1st value) / (1st value)
- Lie factor = (size of effect in graphic) / (size of effect in data)
- In the graphic:

Lie Factor =





D. Koop, CSCI 627/490, Fall 2020

5.3 - 0.6 0.6 14.8 27.5 - 18









(Some of) Tufte's Integrity Principles

- Show data variation, not design variation
- Clear, detailed, and thorough labeling and appropriate scales
- Size of the graphic effect should be directly proportional to the numerical quantities ("lie factor")

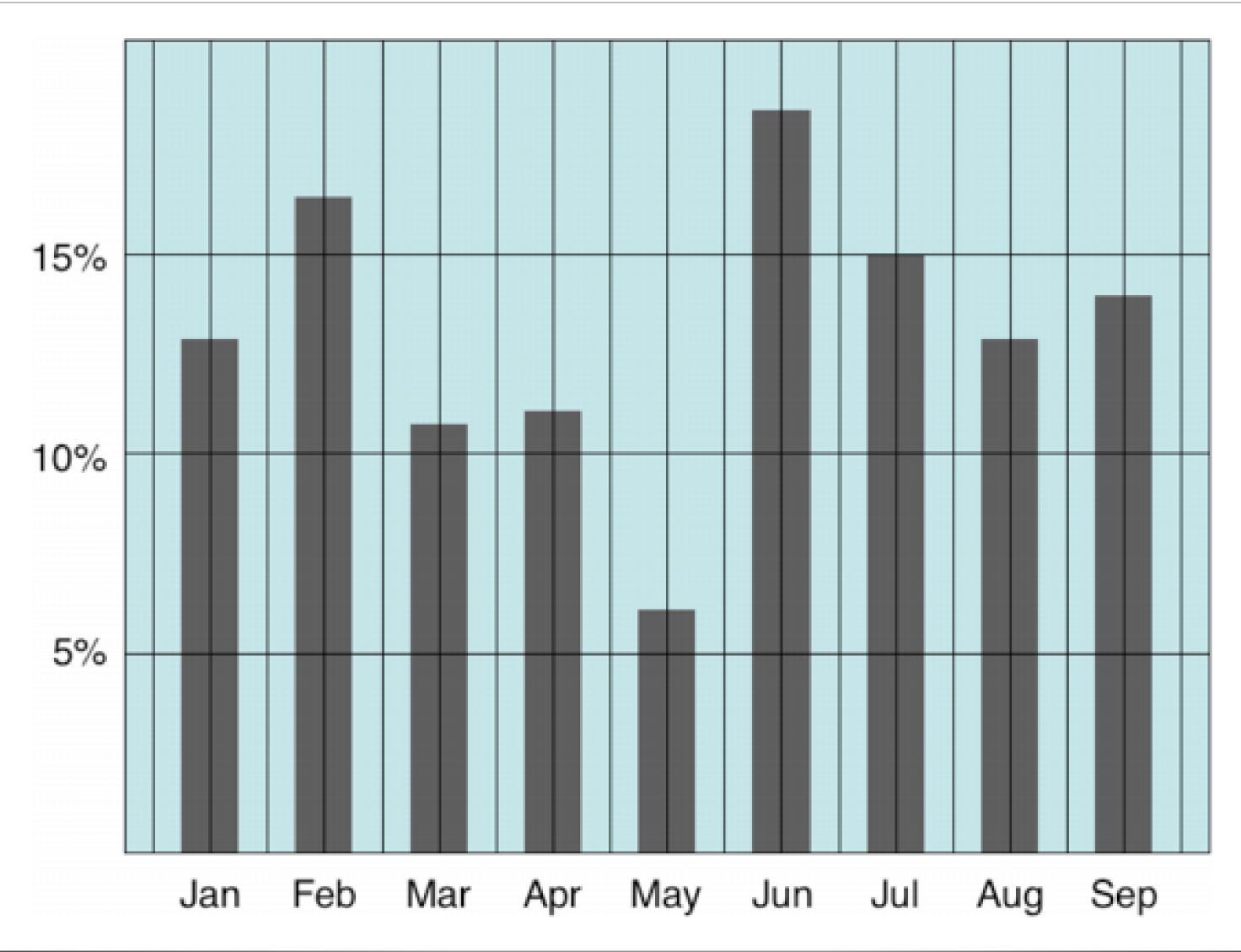








Avoid Chartjunk



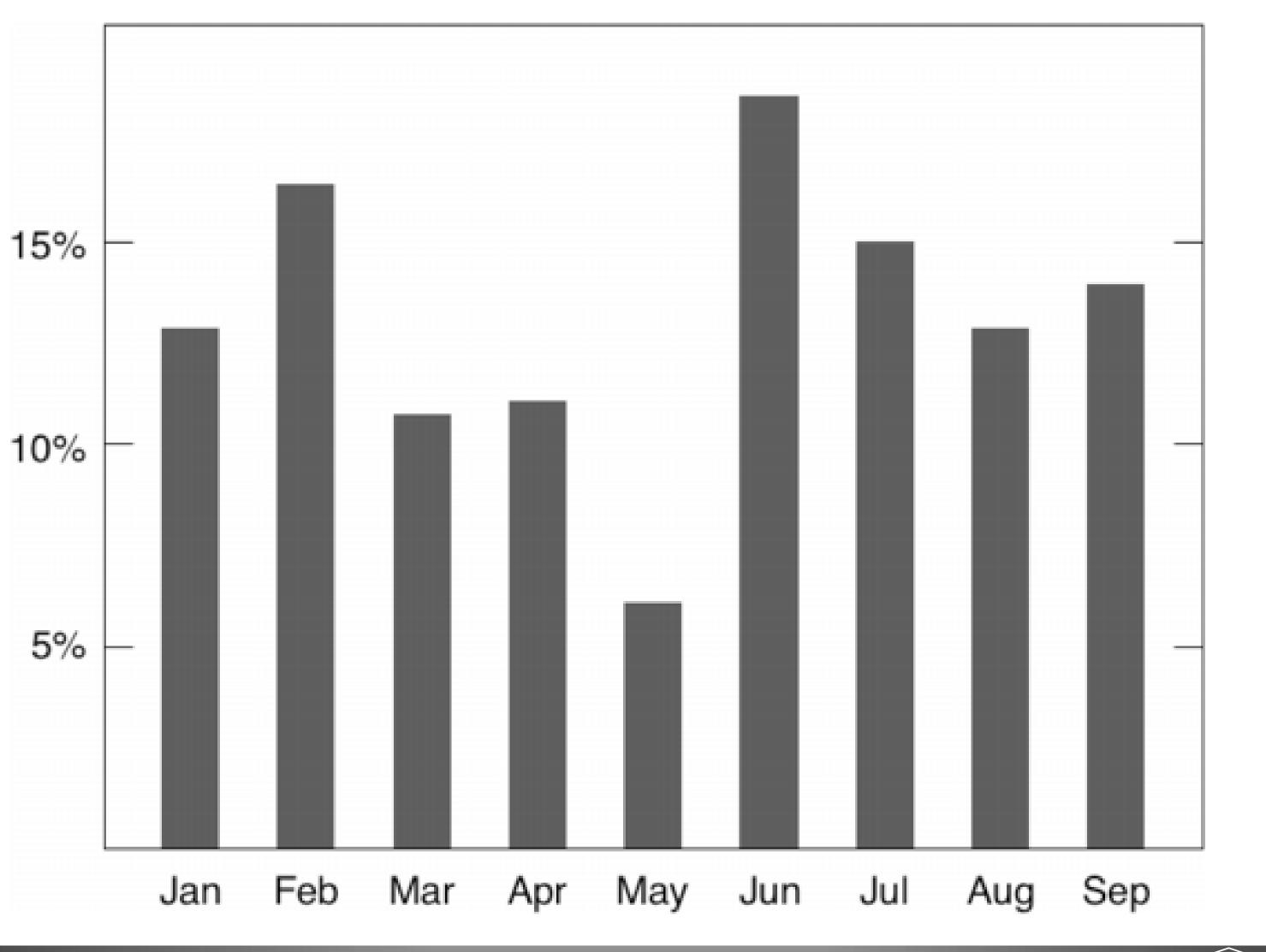








Avoid Chartjunk





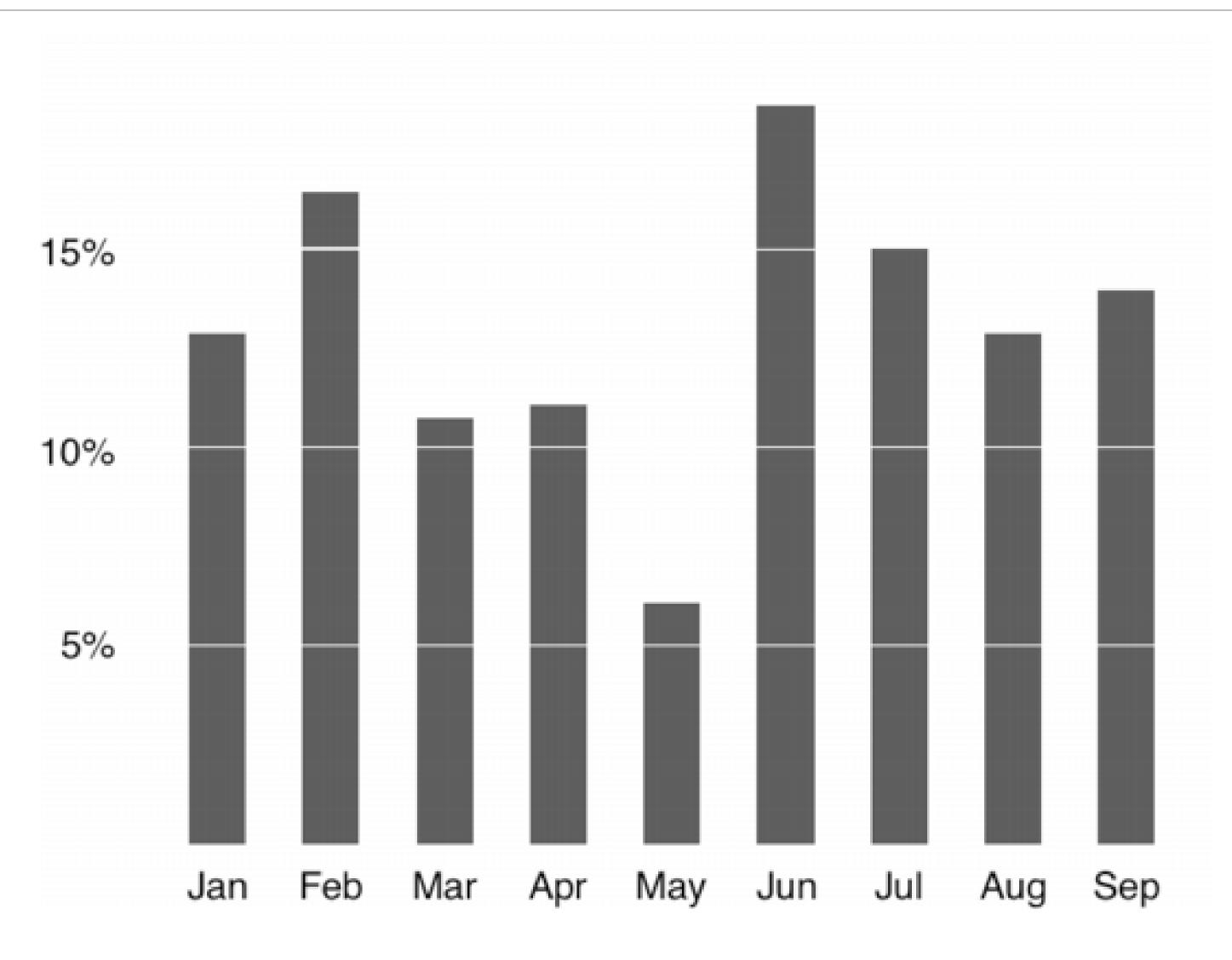








Avoid Chartjunk







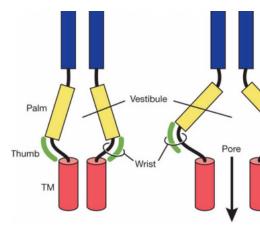






Avoid Chartjunk?





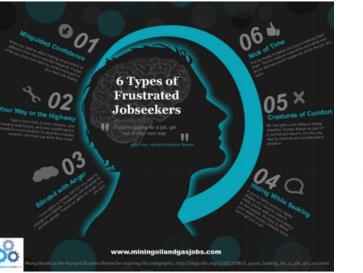
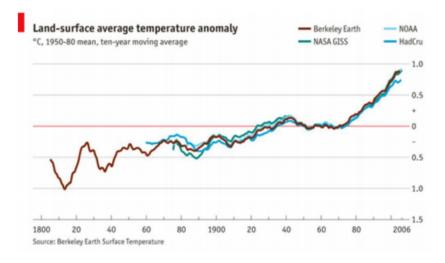
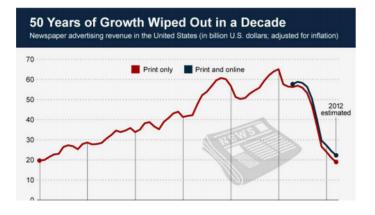


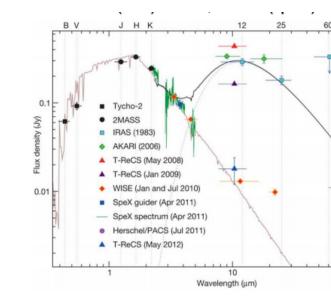


Figure 6.2: Policy shifts and interventions to enable wetland practices to accommodate notions of ecosystem services and human health

Low QUALITY + DESCRIPTION

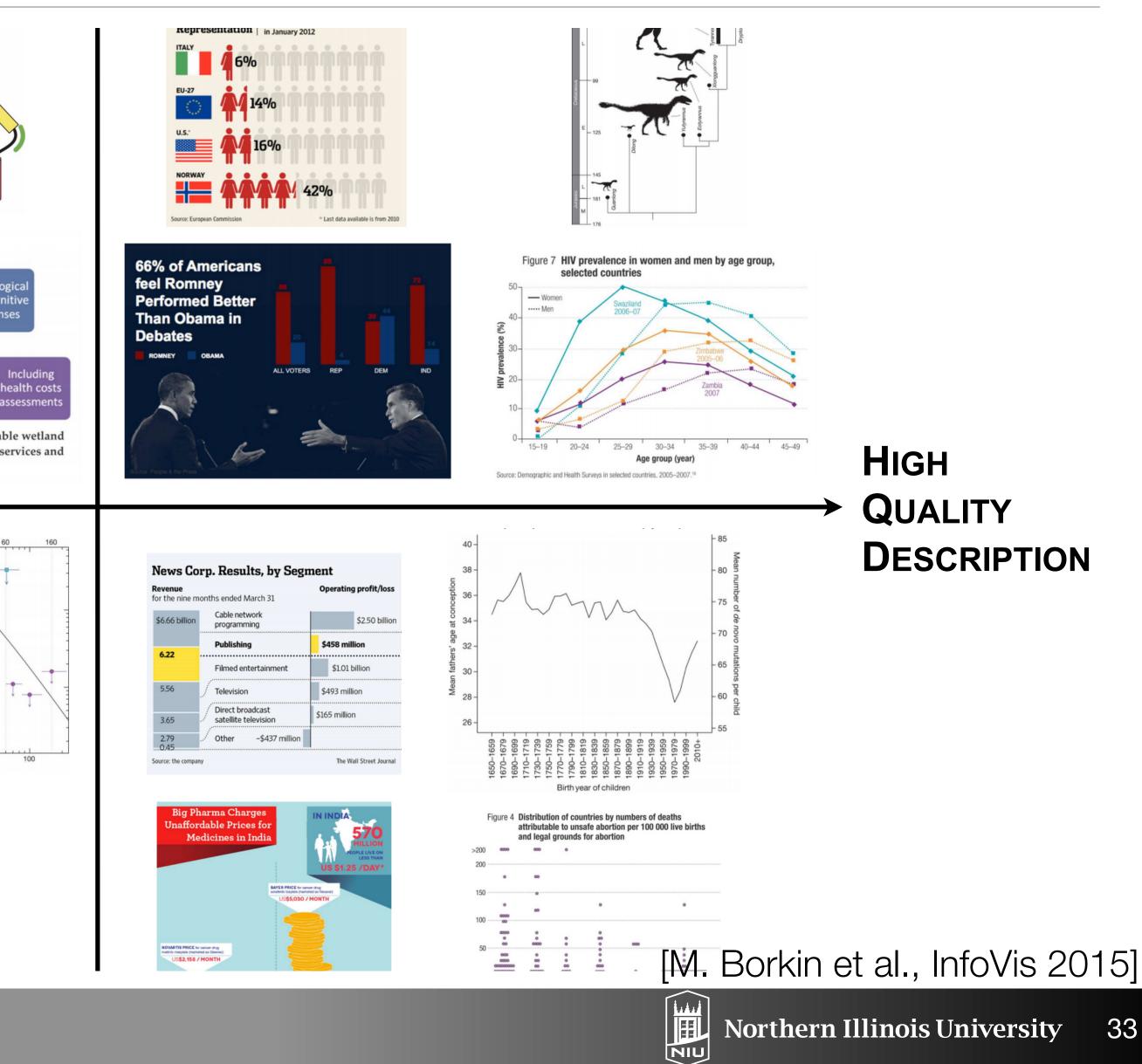






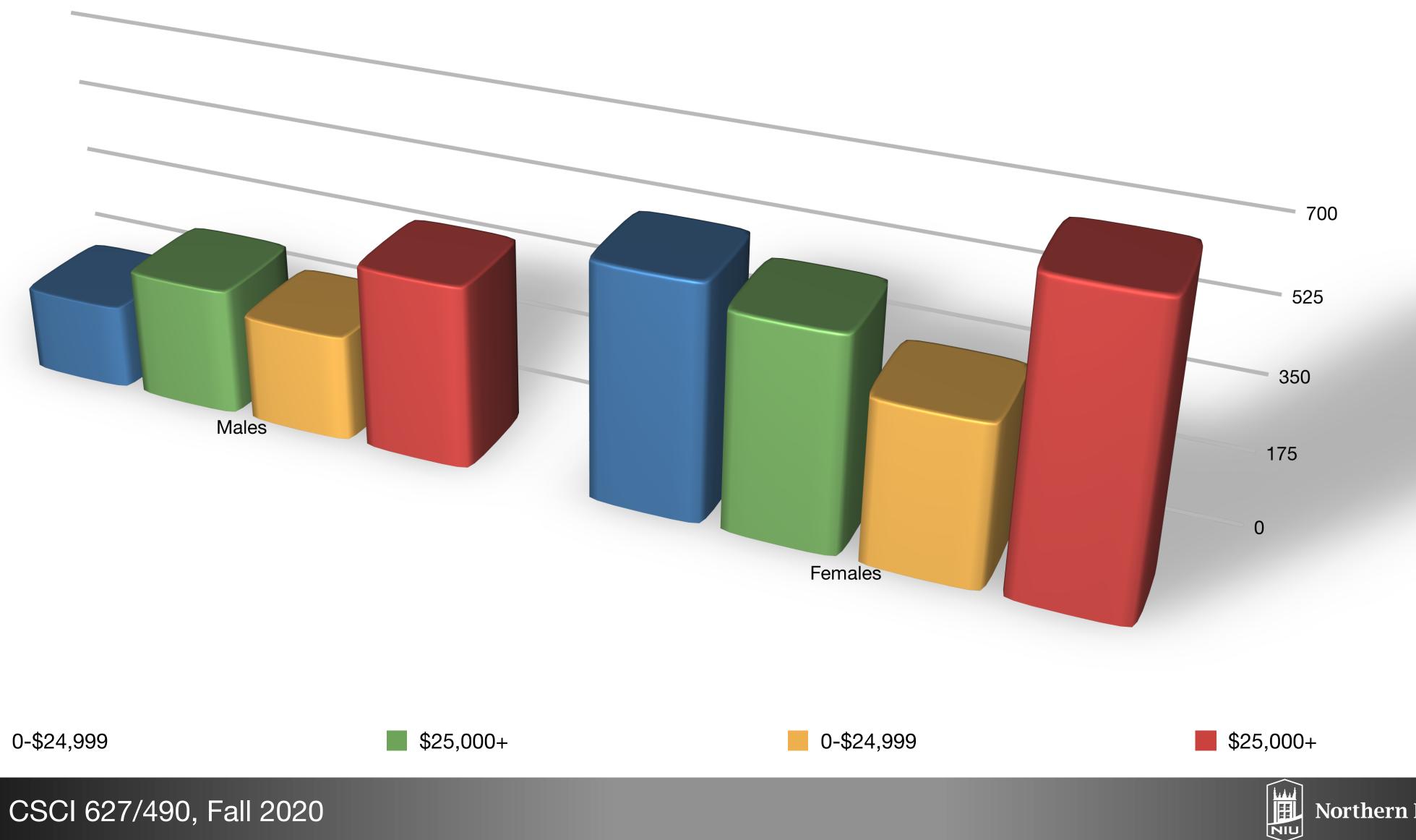


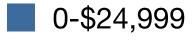
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33

Data-to-Ink Ratio (Also Unjustified 3D)











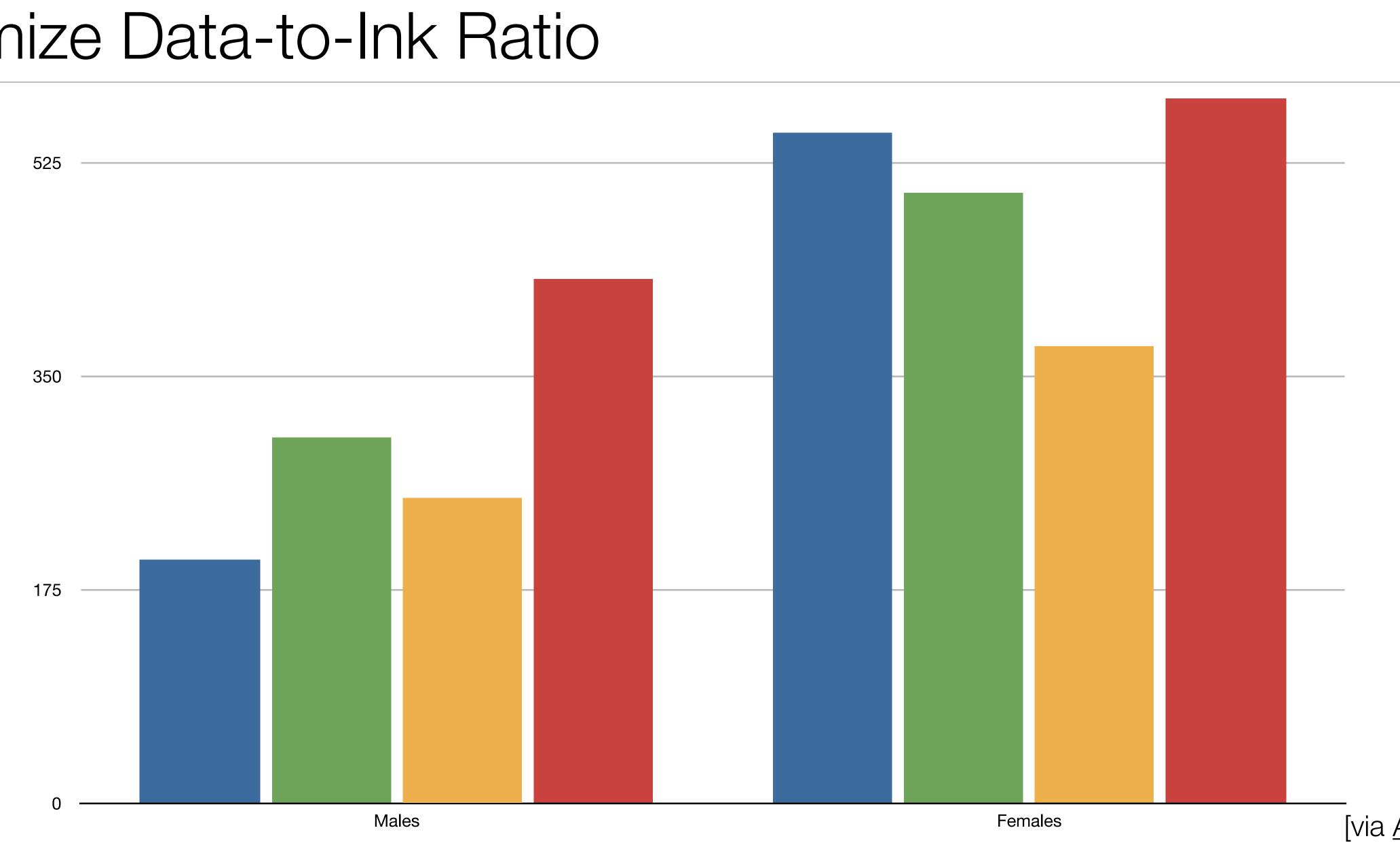




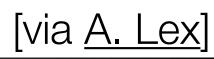


700

Maximize Data-to-Ink Ratio



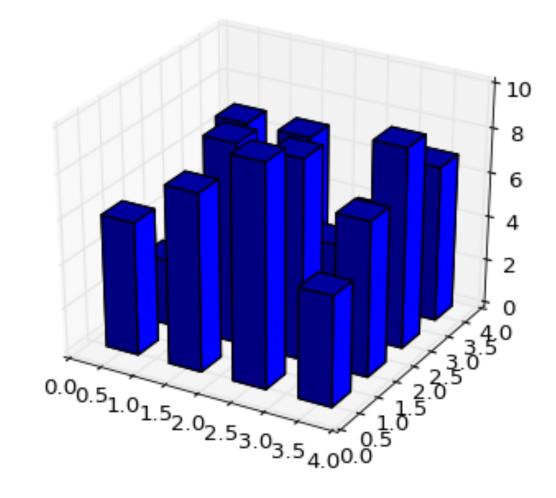


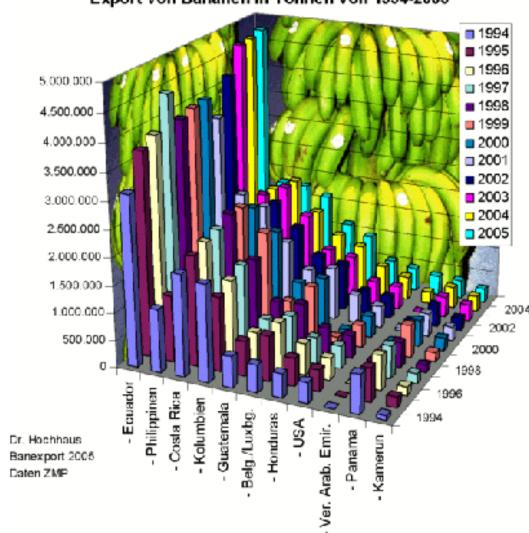






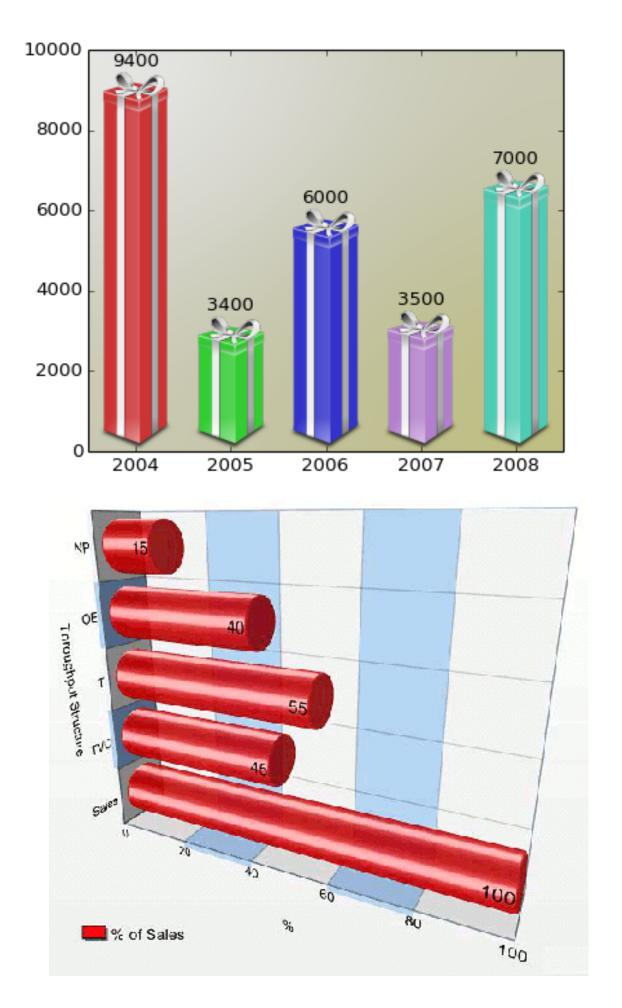
No Unjustified 3D





Export von Bananen in Tonnen von 1994-2005

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matplotlib gallery





Excel Charts Blog

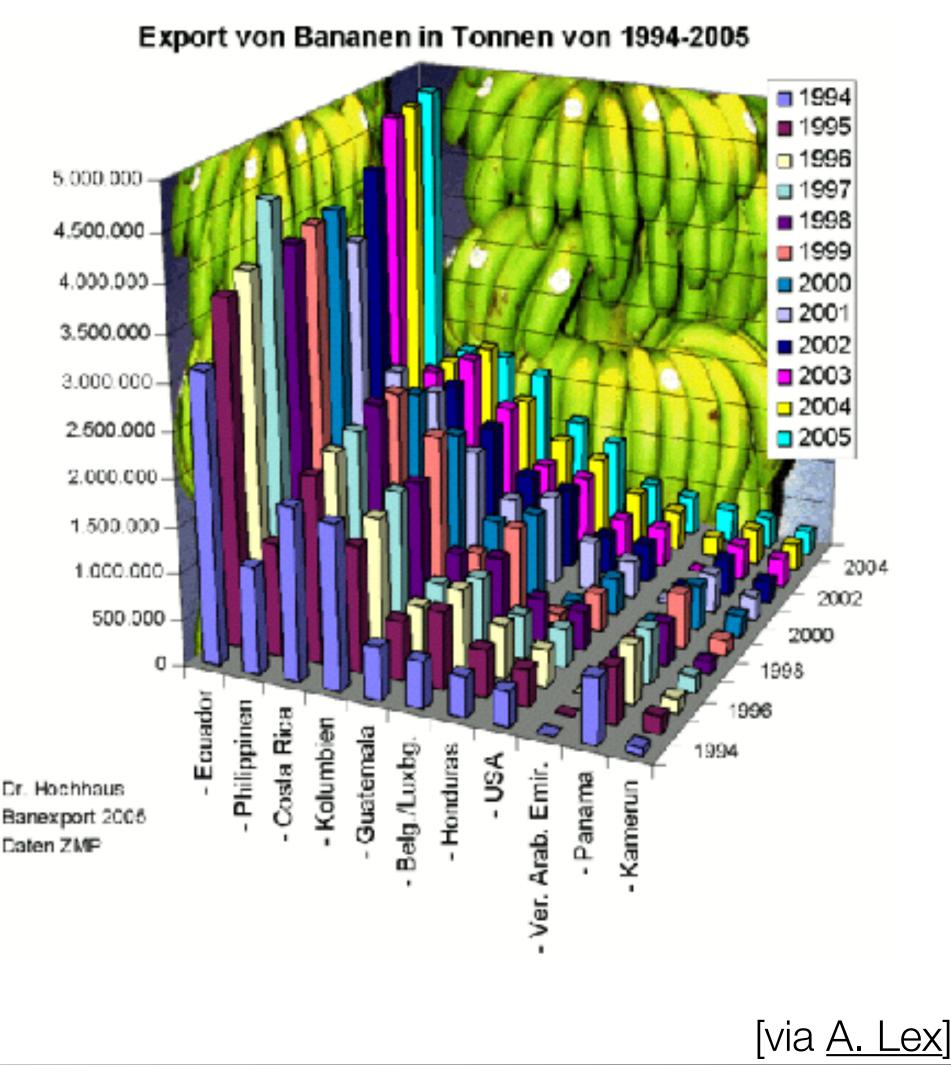






No Unjustified 3D

- Occlusion hides information
- Perspective distortion dangers
- Tilted text isn't legible
- Can help with shape perception









Eyes Beat Memory

- Reduce cognitive load (using up working memory)
- Animation versus side-by-side views
- Change blindness







"Computer-based visualization systems provide visual tasks more effectively."

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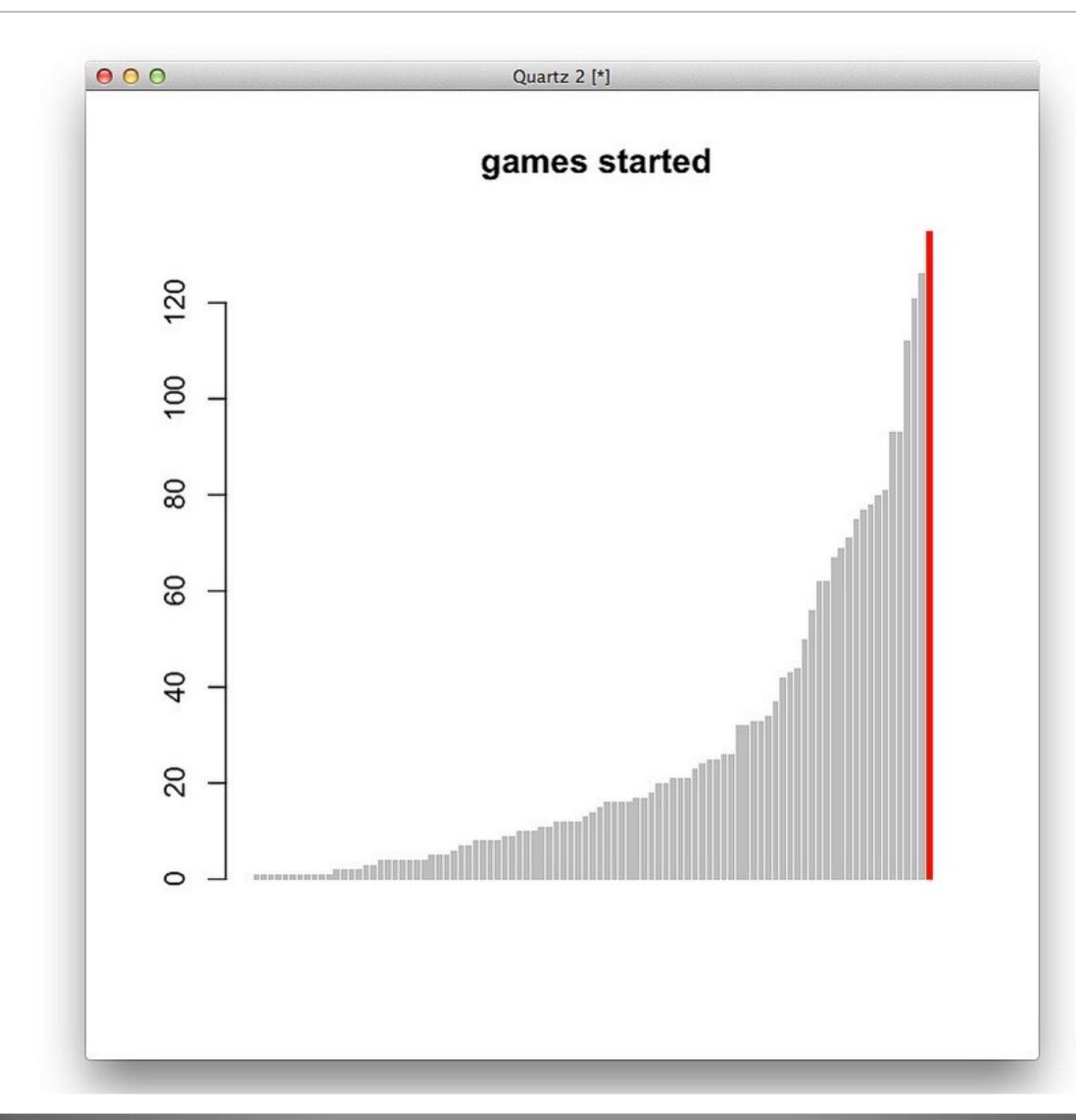
representations of datasets **designed** to help people carry out

– T. Munzner





Design Iteration











Design Iteration

New York Giants Indianapolis Colts San Diego Chargers **Baltimore Ravens New England Patriots Green Bay Packers New Orleans Saints Atlanta Falcons New York Jets** Cincinnati Bengals **Houston Texans Carolina Panthers Denver Broncos Arizona Cardinals Jacksonville Jaguars Detroit Lions** ampa Bay Buccaneers **Dallas Cowboys**

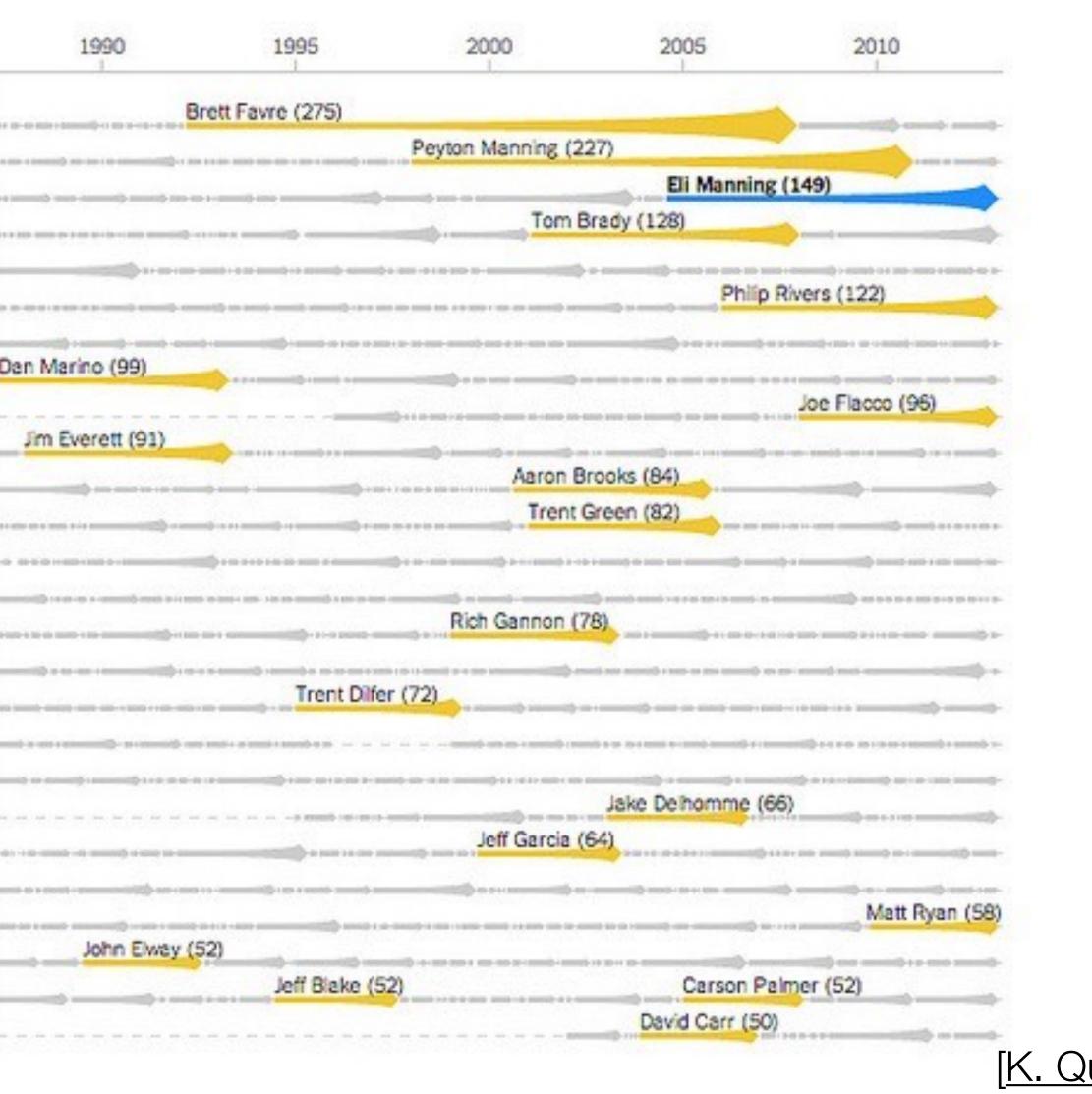
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Drew Brees Drew Brees	Philip Rivers				
Kyle Boller S	teve McNair	Joe Flacco			
Tom Brady		Matt Cassel	Tom Brady		
Brett Favre		Aaron Rodgers		Aaron Rodgers	Aaron Rodgers
Aaron Brooks D	rew Brees		Drew Brees	5	10
Michael Vick Michael V	lick	Matt Ryan	Matt Rya	n	
	Chad Penningtor	Brett Favre M	ark Sanch : Mark Sa	nchez	
Carson Paln Carson Palmer		Ryan Fitzp Carson	Palmer	Andy Dalton	
David Carr		Matt Schar	Jb		Matt Schaub
Jake Delhomme		Jake Delhomme		Cam Newto	on
Jake Plummer	Jay Cutler		Kyle Orton	Tim Tebow	Peyton Manning
	Matt Leina · Kur	t Warner			
Byron Leftwich	David Garrard	David Garrard	1	Blaine Gab	bert
Joey Harrington	Jon Kitna			Matthew Staf	ford
Chris Sim	ms Bruce Gra (Jeff Garci	a	Josh Freema	n	Josh Freeman
Drew Bledsoe	Tony Romo	Tony Romo		Tony Romo	[K

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Design Iteration

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Design

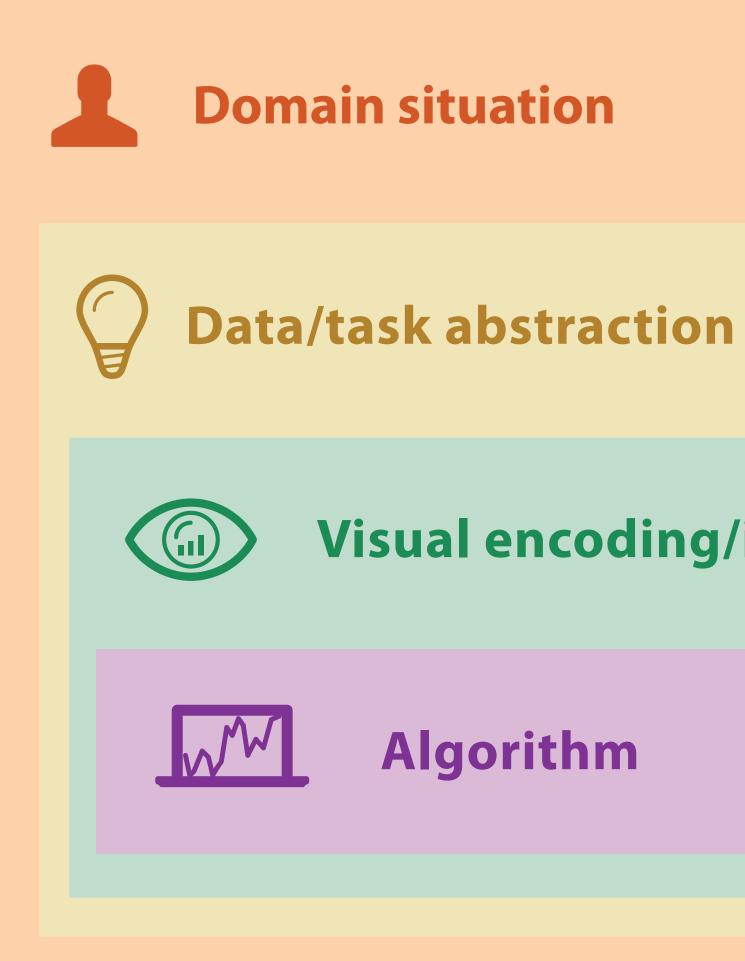
- Unlike a math problem, there are many different approaches for the visualization of some data
- Need to have some way to discuss how to determine whether a visualization is doing what we want
- Validation: Understand why a design is effective
 - What problems can be effective
 - Do this at different levels

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Four Nested Levels of Design



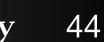
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Visual encoding/interaction idiom









Potential problems at each level

Domain situation You misunderstood their needs

Data/task abstraction You're showing them the wrong thing



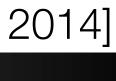
Wisual encoding/interaction idiom The way you show it doesn't work

Algorithm Your code is too slow

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Validation at each level



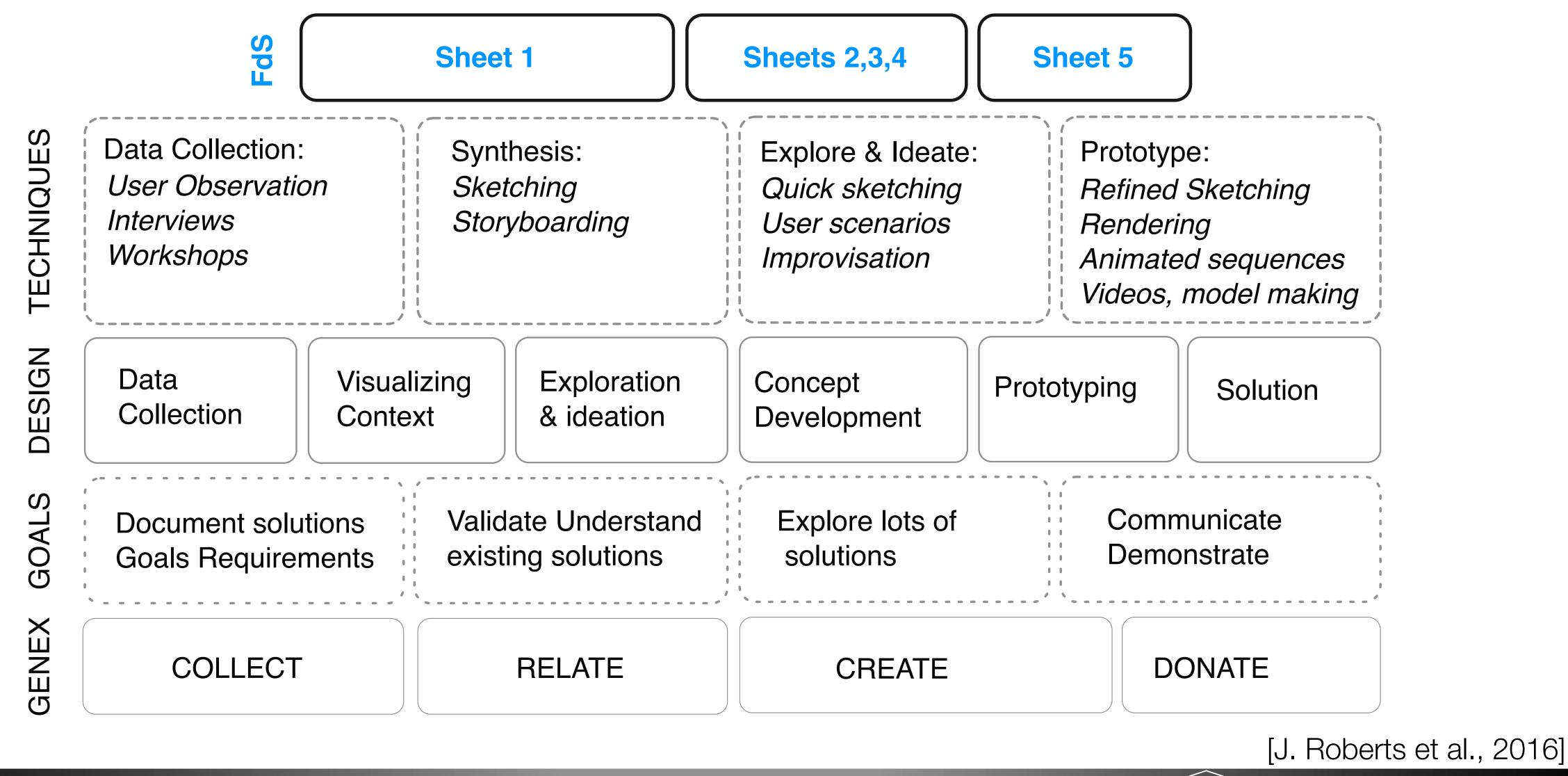
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- Ineffective encoding/interaction idiom
- Validate Test on target users, collect anecdotal evidence of utility Validate Field study, document human usage of deployed system



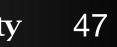


Five Design-Sheet Methodology









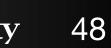
Five Stages

- 1. Meet with client and consider task; or contemplate task on own.
- 2. Ideate and sketch small ideas.
- 3. Sketch and plan three alternative designs.
- 4. Consider solutions with client; or deliberate on own.
- 5. Generate realization sheet, and implement prototype. Discuss with client and re-iterate if necessary.

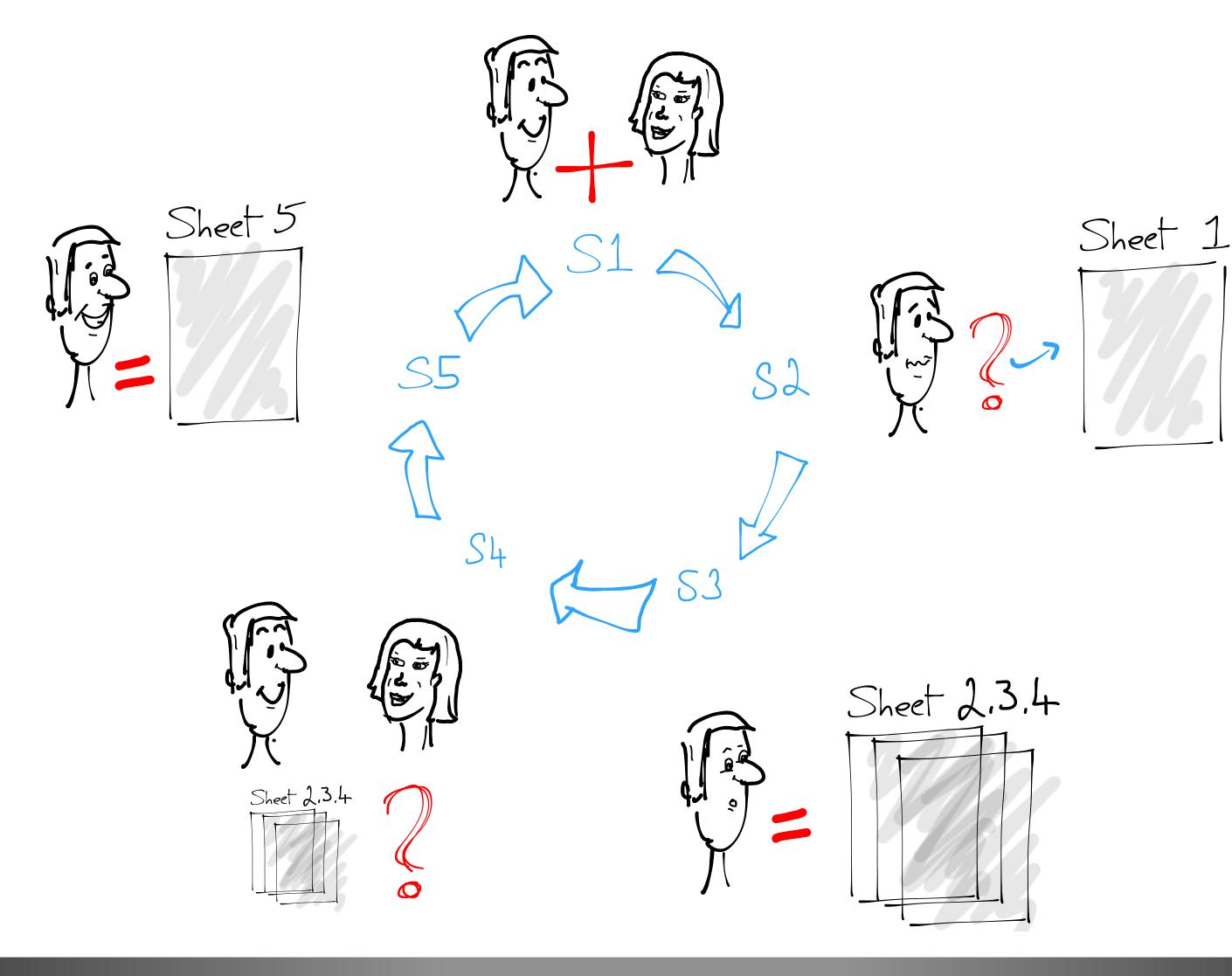








Five Stages



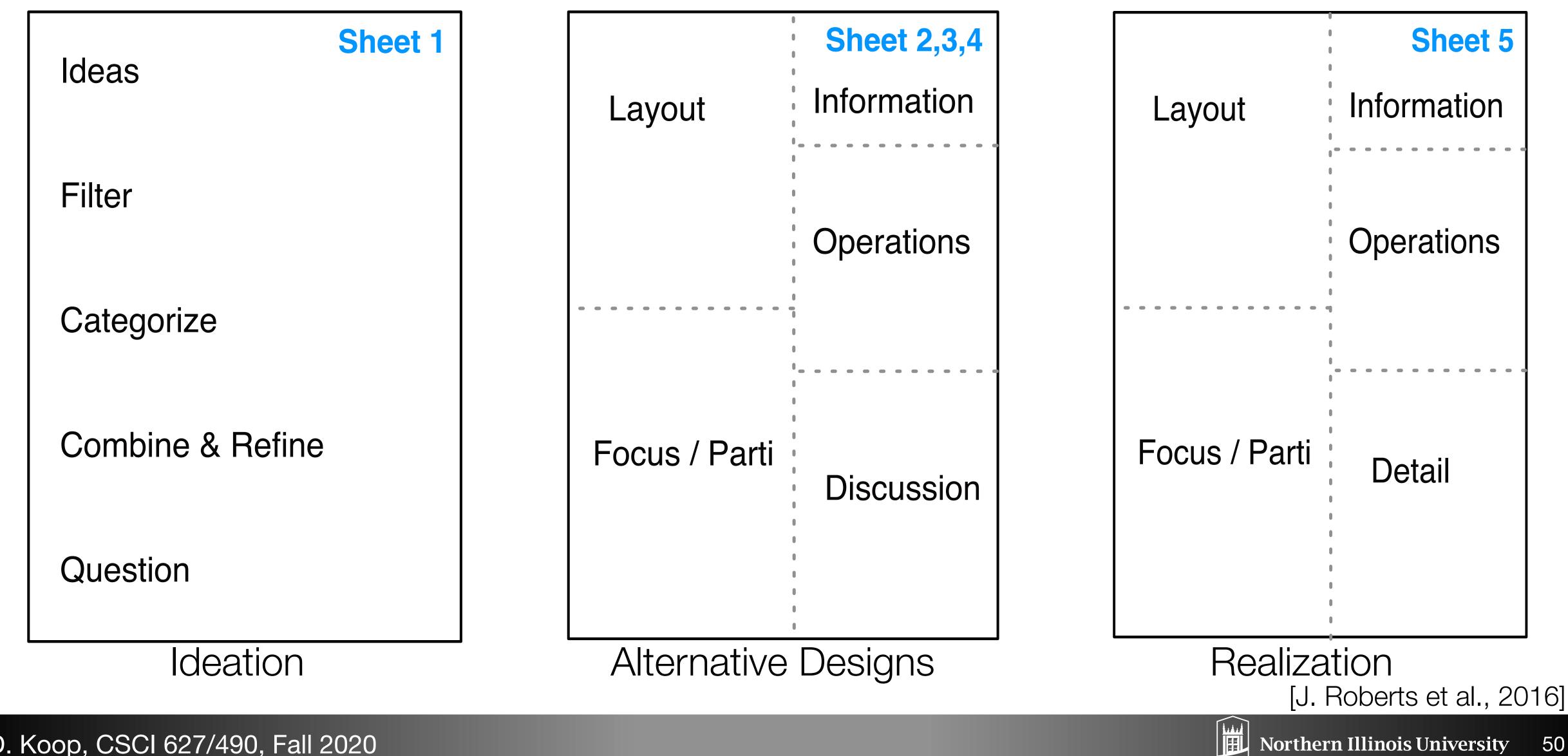




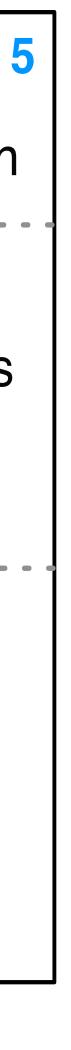




The Five Sheets



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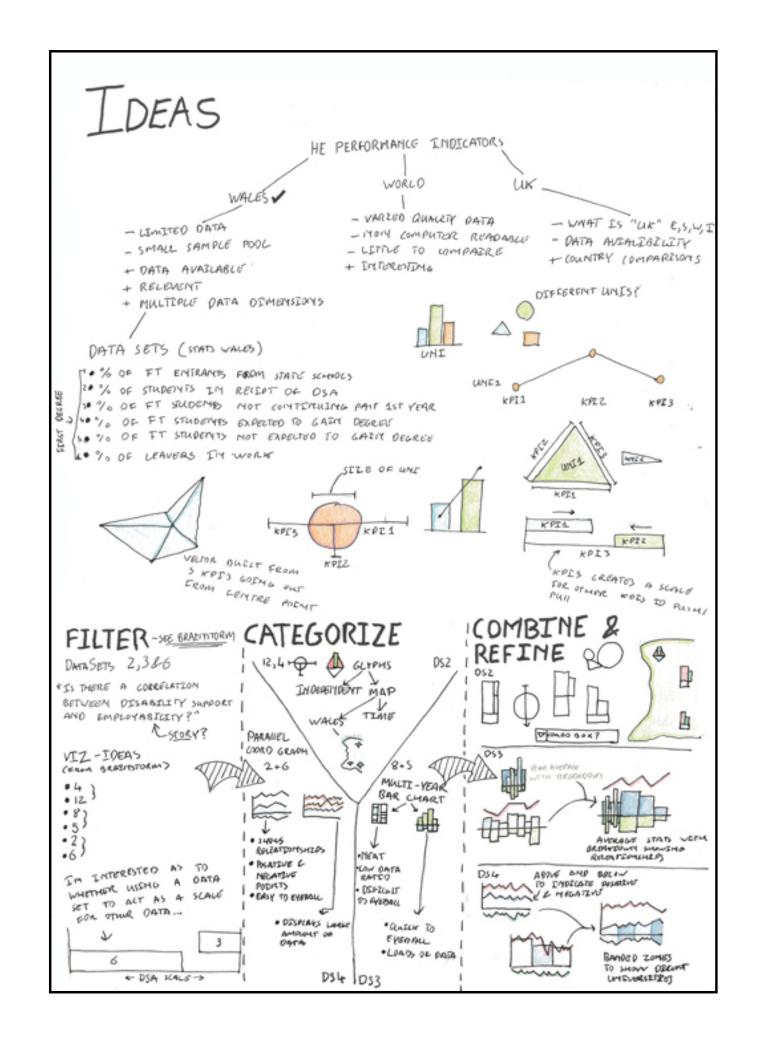


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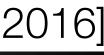


Example: University Access for Disabled Students



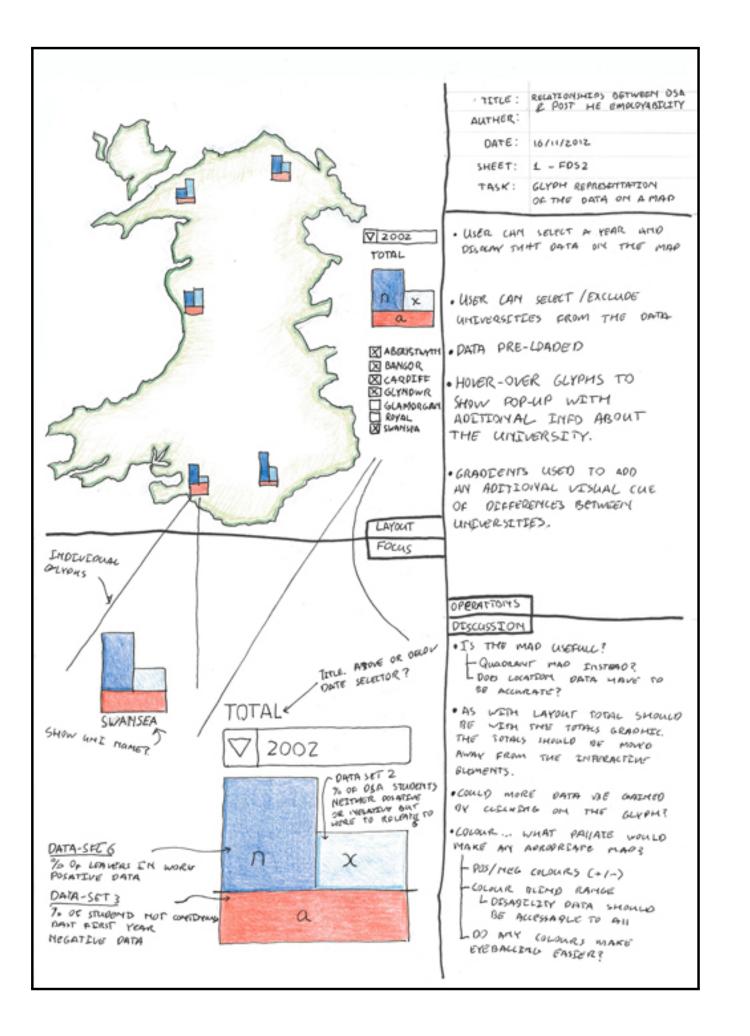


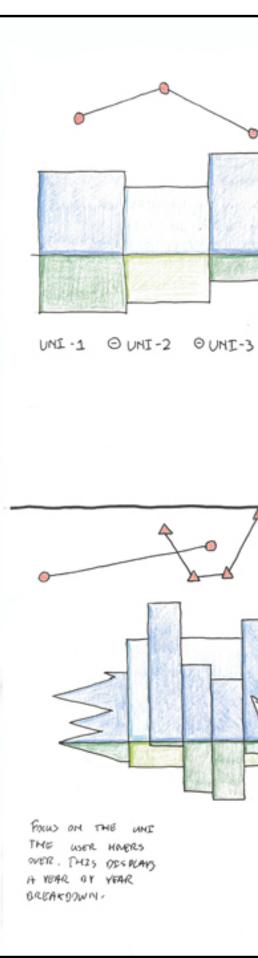






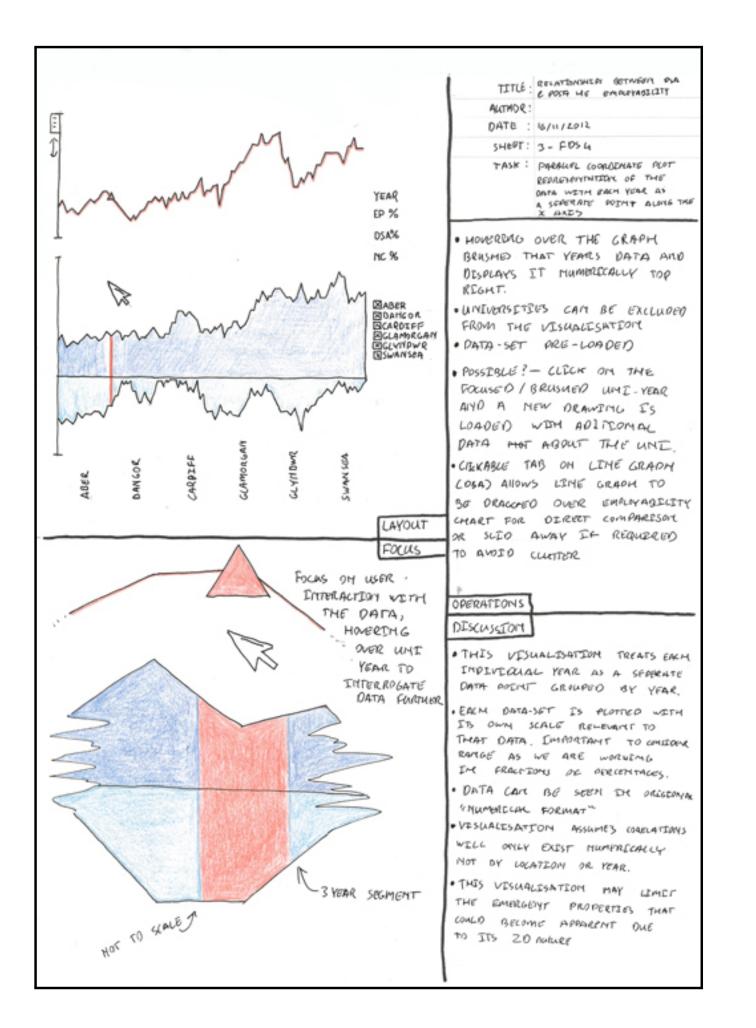
Sheets 2-4





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[J. Roberts et al., 2016]

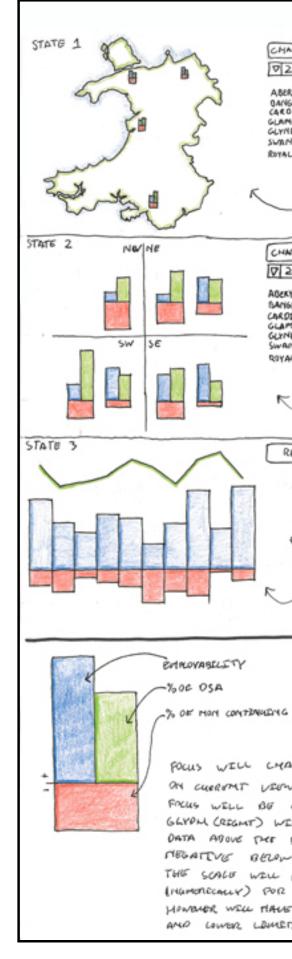








Sheet 5



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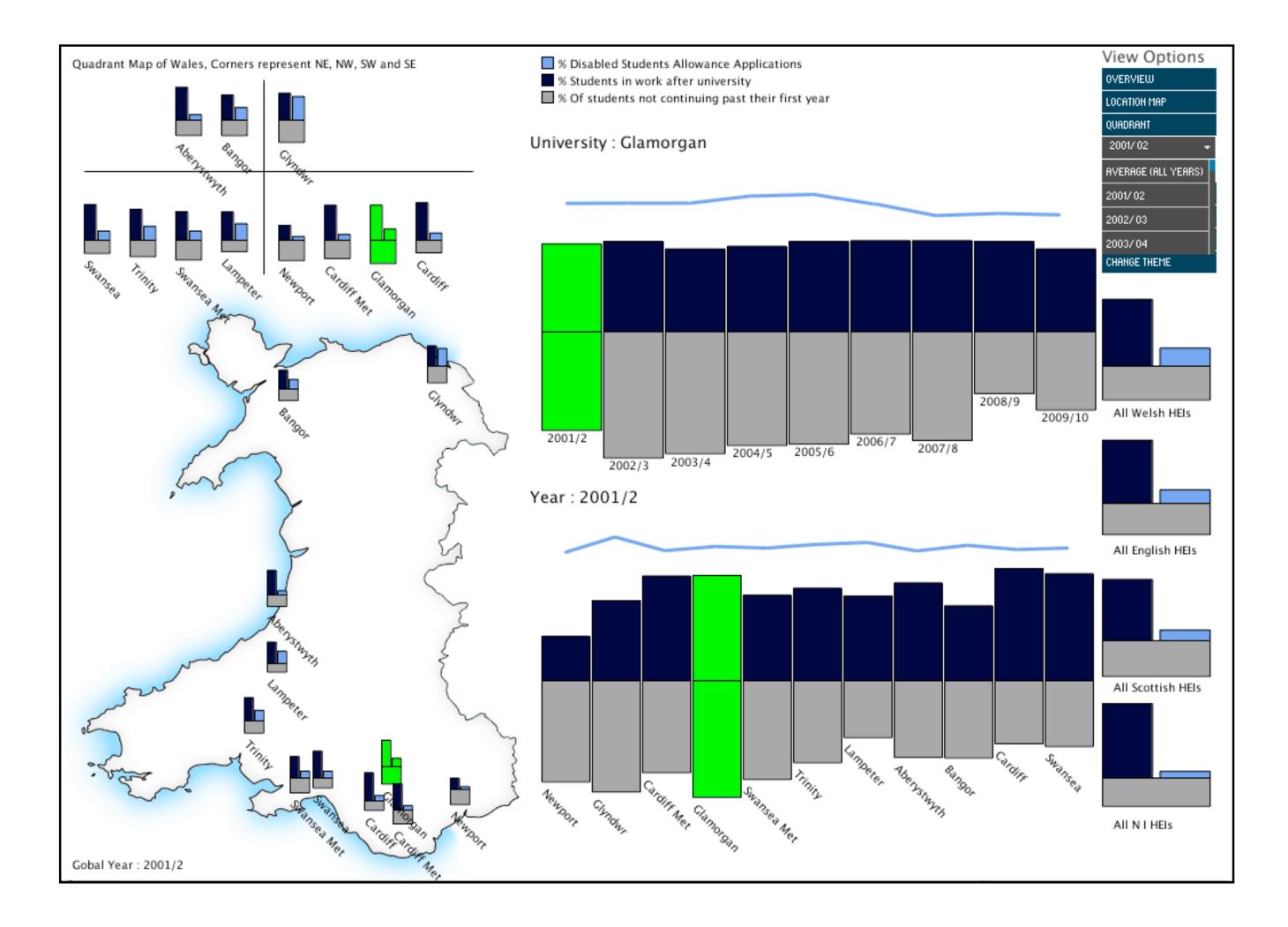


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Prototype



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