## Data Visualization (CSCI 627/490)

Interaction

Dr. David Koop





# What is wrong with here and how can it be fixed?

### **3D Category Scatter**



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2

# Good: Data magnitude <=> Mark magnitude











## Show when the baseline is not zero









## 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 =





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# 5.3 - 0.6 0.6 14.8 27.5 - 18









## Avoid Chartjunk















# No Unjustified 3D

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

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### 



7

# Validation at each level



- 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 Method













## Sheets 2-4





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4.0/	AUTHER:
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	SHEET : 2 - FOS 3
	TASK : BAR - CHART REPRESENTATION
	RE THE OSA, EMPLOYABILITY & LEANERS ONTO
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	OF THAT YEAR ALONE FOR
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	ANY USEFUL INTERALTIONS
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5	BREAK DOWN OF DATA SHOW O
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	· SHOW ALL BUTTON COULD BE
1	WARKUIL BUT IT MAY CLUTTER THE DATA.
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	ON THE GARS? PERCENTAGES OF
	DEGREE CLASSEPECATEON BY TYPE?



#### [J. Roberts et al., 2016]





## <u>Assignment 4</u>

- Crop Production in the US
- Geospatial Visualizations & Treemap
  - Choose colormaps carefully
  - Add legend
- You may use D3 or Observable Plot
  - Part 1a: D3
  - Part 3 will require some D3 for treemap layout







# Project Design

- Feedback will be on Blackboard
- Work on turning your visualization ideas into designs
- Turn in:
  - Three Designs Sketches
  - One Bad Design
  - Progress on Implementation
- Options:
  - Try vastly different options
  - Refine an initial idea
- Due Nov. 15





# Guidelines for Interaction Design





## Interaction

- The view changes over time
- Changes can affect almost any aspect of the visualization
  - encoding
  - arrangement
  - ordering
  - viewpoint
  - attributes being shown
  - aggregation level





## Interaction Overview





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[Munzner (ill. Maguire), 2014]





# Sorting

- Allow user to find patterns by reordering the data
- Do this with tabular data all the time
- Note that categorical attributes don't really need sorting
  - We can compare these attributes no matter what order
  - Instead, sort categorical attribute based on an ordered attribute





## Example: LineUp

			-	
			SUM (Academic reputation, Employer	reputation, Faculty/student ratio, Internation
2.0	School Nama	Country	45.23%	11.31% 32.16%
79	School Name	Eilter	Academic reputation	Employer Paculty/student ratio
	<none></none>	1 out of 50		
1	Massachusetts Institute of Technology (MI	Inited States		
2	Harvard University	United States		
3	Yale University	United States		
4	University of Chicago	United States		
4. 5	University of Pennsylvania	United States		
6	Columbia University	United States		
7	California Institute of Technology (Caltech)	United States		
8	Princeton University	United States		
0.	University of Michigan	United States		
10	New York University (NYU)	United States	97.7 (0.98)	85 3 (0.85) 92 7 (0.93)
11	Johns Honkins University	United States	and formal	and (mary are famo)
12	Duke University	United States		
12.	Cornell University	United States		
1.	Stanford University	United States		
15	University of Wisconsin-Madison	United States		
16	Northwestern University	United States		
17	University of California, Berkeley (UCB)	United States		
18	University of California, Los Angeles (UCL)	United States		
10.	Brown University	United States		
20	University of North Carolina, Chapel Hill	United States		
21	Boston University	United States		
22	University of Illinois at Urbana-Champaign	United States		
23	Washington University in St. Louis	United States		
24	University of Texas at Austin	United States		
25	University of Washington	United States		
06	Purdue University	United States		
7	University of Pittsburgh	United States		
8	University of California, San Diego (UCSD)	United States		
99	Ohio State University	United States		
10	University of Rochester	United States		
21	Pennsylvania State University	United States		
22	University of Maryland, College Park	United States		
13	University of Southern California	United States		
14	Vanderbilt University	United States		
15	Dartmouth College	United States		
6	University of Virginia	United States		
7	Georgia Institute of Technology	United States		
B	University of California. Davis	United States		
9	Rice University	United States		
10	Emory University	United States		
di.		orniou States		



![](_page_16_Picture_4.jpeg)

![](_page_16_Picture_6.jpeg)

![](_page_16_Picture_7.jpeg)

## Example: LineUp

			-	
			SUM (Academic reputation, Employer	reputation, Faculty/student ratio, Internation
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4	University of Chicago	United States		
4. 5	University of Pennsylvania	United States		
6	Columbia University	United States		
7	California Institute of Technology (Caltech)	United States		
8	Princeton University	United States		
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10	New York University (NYU)	United States	97.7 (0.98)	85 3 (0.85) 92 7 (0.93)
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17	University of California, Berkeley (UCB)	United States		
18	University of California, Los Angeles (UCL)	United States		
10.	Brown University	United States		
20	University of North Carolina, Chapel Hill	United States		
21	Boston University	United States		
22	University of Illinois at Urbana-Champaign	United States		
23	Washington University in St. Louis	United States		
24	University of Texas at Austin	United States		
25	University of Washington	United States		
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14	Vanderbilt University	United States		
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9	Rice University	United States		
10	Emory University	United States		
di.		orniou States		

![](_page_17_Figure_3.jpeg)

![](_page_17_Picture_4.jpeg)

![](_page_17_Picture_6.jpeg)

![](_page_17_Picture_7.jpeg)

# Slope Graphs

- Connection marks
- Link the same item appearing in different rows
- highlighted item
- Also called bump charts

Show changes for different attributes (parallel coordinates idea) but with one

![](_page_18_Picture_8.jpeg)

![](_page_18_Picture_10.jpeg)

Q♣	A♣
K♦	Q♣
A♥	J♣
A♦	Q♠
Q♠	J♦
Q♥	Q♦
A♣	J♥
K♠	J♠
K♥	K♦
A♠	K♣
J♥	Q♥
Q♦	K♥
K♣	A♠
J♦	K♠
J♣	A♥
J♠	A♦

- Q♠ K♠ A♦ J♥ A♠ J♣
  - K♠
  - A♣ Q♦
  - K♥
- K♦

![](_page_19_Picture_8.jpeg)

![](_page_19_Picture_10.jpeg)

Q♣	A♣
K♦	Q♣
A♥	J♣
A♦	Q♠
Q♠	J♦
Q♥	Q♦
A♣	J♥
K♠	J♠
K♥	K♦
A♠	K♣
J♥	Q♥
Q♦	K♥
K♣	A♠
J♦	K♠
J♣	A♥
J♠	A♦

- Q♠ K♠ A♦ J♥ A♠ J♣
  - K♠
  - A♣ Q♦
  - K♥
- K♦

![](_page_20_Picture_8.jpeg)

![](_page_20_Picture_10.jpeg)

Q♣	A♣
K♦	Q♣
A♥	J♣
A♦	Q♠
Q♠	J♦
Q♥	Q♦
A♣	J♥
K♠	J♠
K♥	K♦
A♠	K♣
J♥	Q♥
Q♦	K♥
K♣	A♠
J♦	K♠
J♣	A♥
J♠	A♦

- Q♠ K♠ A♦ J♥ A♠ J♣
  - K♠
  - A♣ Q♦
  - K♥
- K♦

![](_page_21_Picture_8.jpeg)

![](_page_21_Picture_10.jpeg)

Q♣	A♣
K♦	Q♣
A♥	J♣
A♦	Q♠
Q♠	J♦
Q♥	Q♦
A♣	J♥
K♠	J♠
K♥	K♦
A♠	K♣
J♥	Q♥
Q♦	K♥
K♣	A♠
J♦	K♠
J♣	A♥
J♠	A♦

- Q♠ K♠ A♦ J♥ A♠ J♣
  - K♠
  - A♣ Q♦
  - K♥
- K♦

![](_page_22_Picture_8.jpeg)

![](_page_22_Picture_10.jpeg)

## Side-by-side views

Q♣
K♦
A♥
A♦
Q♠
Q♥
A♣
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K♥
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K♣			
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![](_page_23_Picture_4.jpeg)

![](_page_23_Picture_6.jpeg)

![](_page_23_Picture_7.jpeg)

![](_page_23_Picture_8.jpeg)

## Side-by-side views

Q♣
K♦
A♥
A♦
Q♠
Q♥
A♣
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J♥			

![](_page_24_Picture_4.jpeg)

![](_page_24_Picture_6.jpeg)

![](_page_24_Picture_7.jpeg)

![](_page_24_Picture_8.jpeg)

## Animated Transitions

![](_page_25_Figure_3.jpeg)

![](_page_25_Picture_5.jpeg)

![](_page_25_Picture_7.jpeg)

![](_page_25_Picture_8.jpeg)

## Animated Transitions

![](_page_26_Figure_3.jpeg)

![](_page_26_Picture_5.jpeg)

![](_page_26_Picture_7.jpeg)

![](_page_26_Picture_8.jpeg)

# Animated Transitions

- "Jump cuts" are hard to follow
- Animations help users maintain sense of context between two states
- Empirical study showed that they work (Heer & Robertson, 2007)

![](_page_27_Picture_6.jpeg)

![](_page_27_Picture_8.jpeg)

![](_page_27_Picture_9.jpeg)

![](_page_27_Picture_10.jpeg)

# Studying Animated Transitions

![](_page_28_Picture_1.jpeg)

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![](_page_28_Picture_3.jpeg)

![](_page_28_Picture_4.jpeg)

Northern Illinois University

![](_page_28_Picture_6.jpeg)

![](_page_28_Picture_7.jpeg)

![](_page_28_Picture_8.jpeg)

# Studying Animated Transitions

![](_page_29_Picture_1.jpeg)

D. Koop, CSCI 627/490, Fall 2024

![](_page_29_Picture_3.jpeg)

![](_page_29_Picture_4.jpeg)

Northern Illinois University

![](_page_29_Picture_6.jpeg)

![](_page_29_Picture_7.jpeg)

![](_page_29_Picture_8.jpeg)

# Design Considerations

- Based on Tversky et al.'s Congruence and Apprehension Principles
- Congruence (Expressiveness):
  - Use consistent semantic-syntactic mappings
  - Respect semantic correspondence
  - Avoid ambiguity

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- Apprehension (Effectiveness):
  - Group similar transitions
  - Minimize occlusion
  - Maximize predictability
  - Use simple transitions
  - Use staging for complex transitions
  - Transitions as long as needed, but no longer

![](_page_30_Picture_14.jpeg)

![](_page_30_Picture_15.jpeg)

![](_page_30_Picture_17.jpeg)

24

![](_page_30_Figure_18.jpeg)

# Experiment 1 (Syntactic)

- of the objects in the final graphic
- Tests: bar chart to donut chart, stacked to grouped bars, sorting a bar chart, scatter plot to bar chart, timestep in a scatterplot
- Either a jump cut or an animated transition
- Users pick highlighted elements after transition (measure #pixels from correct)

![](_page_31_Figure_5.jpeg)

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Object Tracking: Follow objects across a transition and identify the locations

![](_page_31_Picture_8.jpeg)

![](_page_31_Picture_9.jpeg)

![](_page_31_Picture_10.jpeg)

![](_page_31_Picture_11.jpeg)

# Experiment 2 (Semantic)

- est mate the percentage change in value
  - Tesster a sresc ling + timester anim tions
- to 90% or click "?" for no idea)

![](_page_32_Figure_5.jpeg)

![](_page_32_Figure_7.jpeg)

![](_page_32_Picture_8.jpeg)

![](_page_32_Picture_9.jpeg)

![](_page_32_Picture_10.jpeg)

![](_page_32_Picture_11.jpeg)

![](_page_33_Figure_0.jpeg)

# Results/Conclusions Stacked Bars

• User Preferences: Staged animation > animation > static transitions

![](_page_33_Figure_3.jpeg)

- Animation improves graphical perception
- Staging is better (do axis rescaling before value changes)
- Avoid axis rescaling when possible

![](_page_33_Picture_11.jpeg)

![](_page_33_Picture_12.jpeg)

![](_page_33_Picture_14.jpeg)

![](_page_33_Picture_15.jpeg)

![](_page_33_Picture_16.jpeg)

![](_page_33_Picture_17.jpeg)

# Change Blindness

### • <u>https://www.youtube.com/watch?v=uO8wpm9HSB0</u>

![](_page_34_Picture_2.jpeg)

![](_page_34_Picture_4.jpeg)

![](_page_34_Picture_6.jpeg)

![](_page_34_Picture_7.jpeg)

![](_page_34_Picture_8.jpeg)

# Change Blindness

### • <u>https://www.youtube.com/watch?v=uO8wpm9HSB0</u>

![](_page_35_Picture_2.jpeg)

![](_page_35_Picture_4.jpeg)

![](_page_35_Picture_6.jpeg)

![](_page_35_Picture_7.jpeg)

![](_page_35_Picture_8.jpeg)

# Selection

- Selection is often used to initiate other changes
- User needs to select something to drive the next change
- What can be a selection target?
  - Items, links, attributes, (views)
- How?
  - mouse click, mouse hover, touch
  - keyboard modifiers, right/left mouse click, force
- Selection modes:
  - Single, multiple
  - Contiguous?

![](_page_36_Picture_14.jpeg)

![](_page_36_Picture_16.jpeg)

![](_page_36_Picture_17.jpeg)

![](_page_36_Picture_18.jpeg)

# Highlighting

- Selection is the user action
- Feedback is important!
- How? Change selected item's visual encoding
  - Change color: want to achieve visual popout
  - Add outline mark: allows original color to be preserved

\_ \_ \_ \_ \_

- Change size (line width)
- Add motion: marching ants

(II)	Contacts
	Dashboard
Aa	Dictionary
- 😵	Dropbox
8	DVD Player
3	Emacs
-0	FaceTime
Æ	FileZilla
8	Firefox

![](_page_37_Picture_11.jpeg)

![](_page_37_Picture_13.jpeg)

![](_page_37_Picture_14.jpeg)

# Highlighting

- Selection is the user action
- Feedback is important!
- How? Change selected item's visual encoding
  - Change color: want to achieve visual popout
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\_ \_ \_ \_ \_

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![](_page_38_Picture_11.jpeg)

![](_page_38_Picture_13.jpeg)

![](_page_38_Picture_14.jpeg)

# Highlighting

![](_page_39_Figure_1.jpeg)

![](_page_39_Picture_3.jpeg)

![](_page_39_Picture_5.jpeg)

![](_page_39_Picture_6.jpeg)

![](_page_39_Picture_7.jpeg)

# Selection Outcomes

- Selection is usually a part of an action sequence
- Can filter, aggregate, reorder selected items

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### on sequence ed items

![](_page_40_Picture_5.jpeg)

![](_page_40_Picture_7.jpeg)

![](_page_40_Picture_8.jpeg)

## Responsiveness Required

- Delays are perceived by users
- Visual feedback
  - Show the user they did something (highlighting, etc)
  - Interaction should happen quick!
- Latency: mouse click versus mouse hover
- Popup versus detail displays

![](_page_41_Picture_10.jpeg)

![](_page_41_Picture_12.jpeg)

![](_page_41_Picture_13.jpeg)

# Interaction Latency

- The Effects of Interactive Latency on Exploratory Visual Analysis, Z. Liu and J. Heer, 2014
- Brush & link, select, pan, zoom

![](_page_42_Figure_3.jpeg)

- 500ms added latency causes significant cost - decreases user activity and dataset coverage - reduces rate of observations, generalizations, and hypotheses

![](_page_42_Picture_9.jpeg)

![](_page_42_Picture_11.jpeg)

![](_page_42_Picture_13.jpeg)