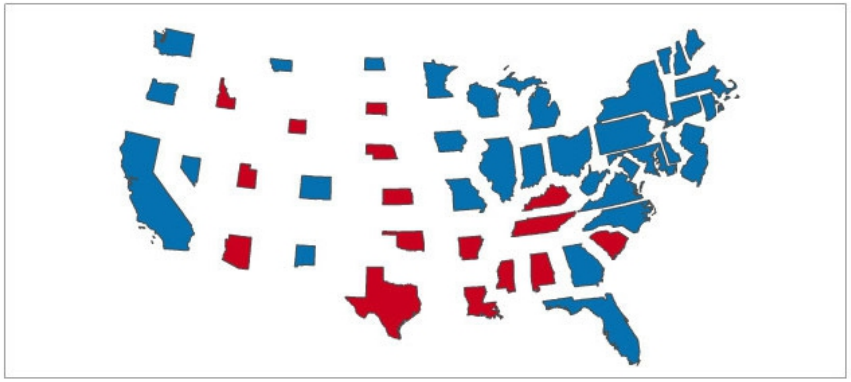
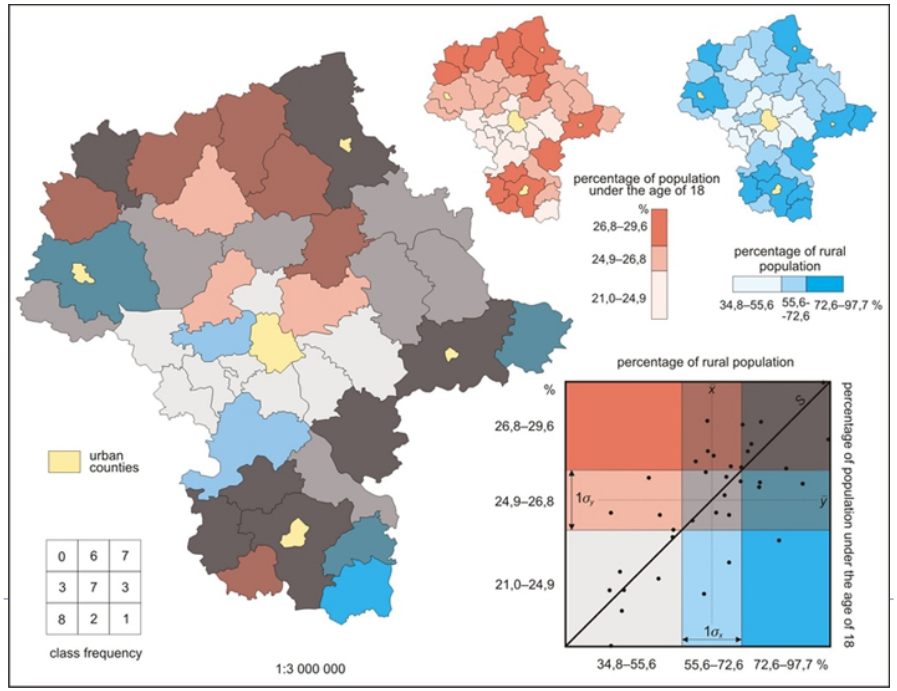
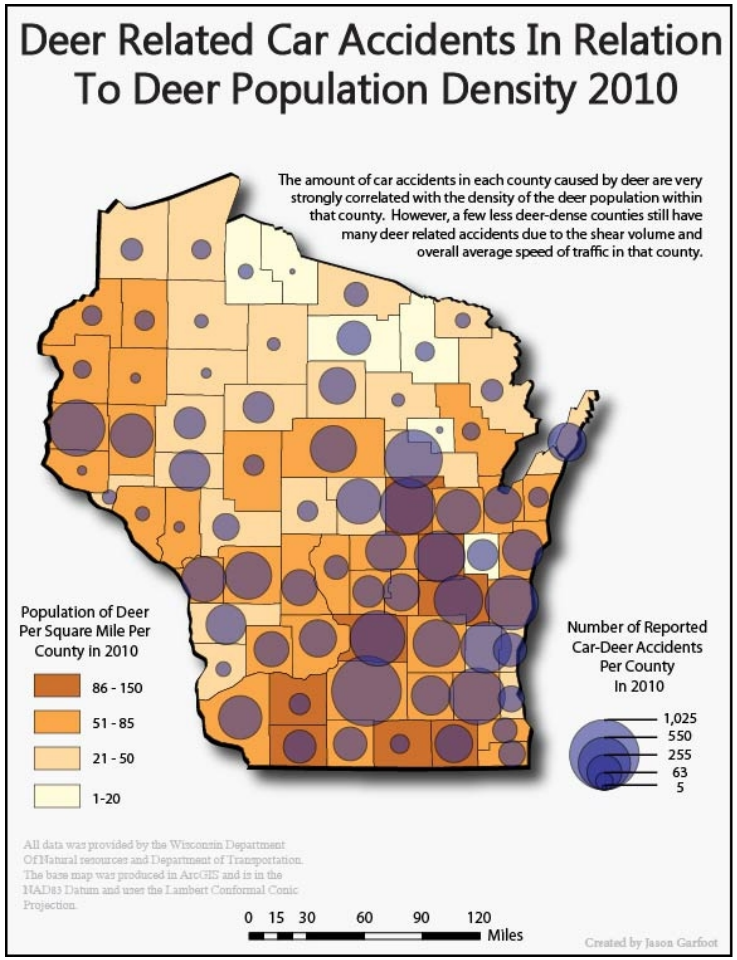
Symbol Considerations for Bivariate Thematic Maps

Martin Elmer

Outline




percentage of population under the age of 18
%
26,8–29,6
24,9–26,8
21,0–24,9
percentage of rural population
34,8–55,6
55,6-72,6
72,6–97,7 %
urban counties
0 6 7
3 7 3
8 2 1
class frequency
1:3 000 000
percentage of rural population
%
26,8–29,6
24,9–26,8
21,0–24,9
34,8–55,6
55,6–72,6
72,6–97,7 %
percentage of population under the age of 18

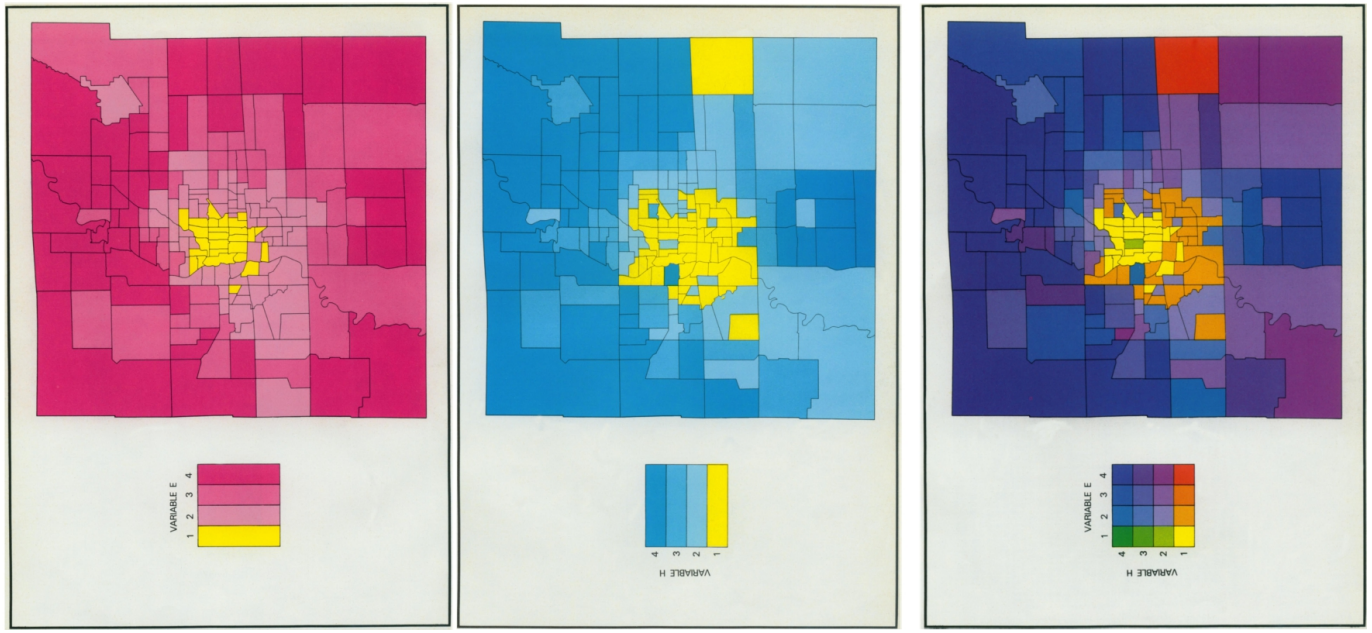

Deer Related Car Accidents In Relation To Deer Population Density 2010
The amount of car accidents in each county caused by deer are very strongly correlated with the density of the deer population within that county. However, a few less deer-dense counties still have many deer related accidents due to the shear volume and overall average speed of traffic in that county.
Population of Deer Per Square Mile Per County in 2010
86 - 150
51 - 85
21 - 50
1-20
Number of Reported Car-Deer Accidents Per County In 2010
1,025
550
255
63
5
All data was provided by the Wisconsin Department Of Natural resources and Department of Transportation. The base map was produced in ArcGIS and is in the NAD83 Datum and uses the Lambert Conformal Conic Projection.
0 15 30 60 90 120
Miles
Created by Jason Garfoot

Outline

- *How Bivariate Maps Work*
- *Bivariate Maps and Selective Attention*
- *An Empirical Study on Bivariate Maps*

How Bivariate Maps Work

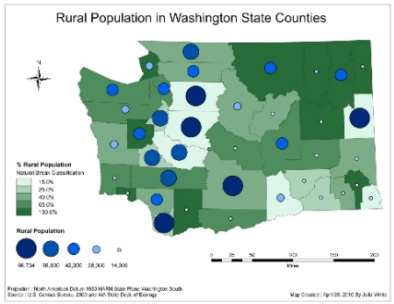
- ***"I'm glad you're researching bivariate maps, because I hate them."***
- Bivariate maps are **powerful** but **have a problem**

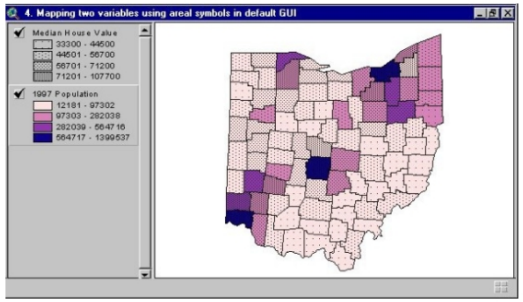


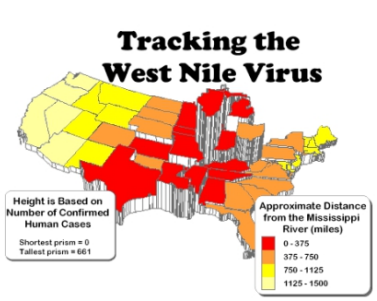
How Bivariate Maps Work

- Our understanding of bivariate maps is less than systematic.

Fisher	Robinson	Slocum	Dent	Tyner	Krygier & Wood
Multiseries Graduated Symbol					
Choropleth w/ Graduated Symbol				Choropleth w/ Graduated Symbol	Choropleth w/ Graduated Symbol
Bar Graph					
Multiseries Dot Density			Multiseries Dot Density	Multiseries Dot Density	
	Graduated Pie Charts			Graduated Pie Charts	
		Bivariate Choropleth	Bivariate Choropleth	Bivariate Choropleth	
		Ray Glyph			
		Rectangles (height/width)			
			Shaded Cartogram		Shaded Cartogram
			Shaded Proportional Symbols		Shaded Proportional Symbols
					Isoline w/ Graduated Symbol







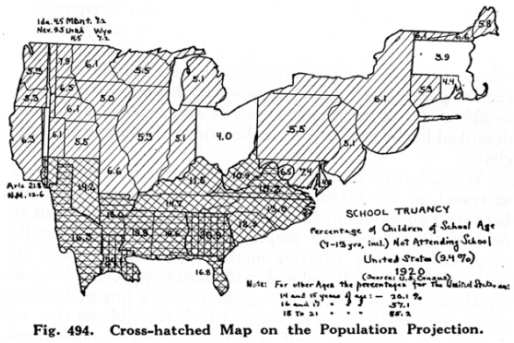
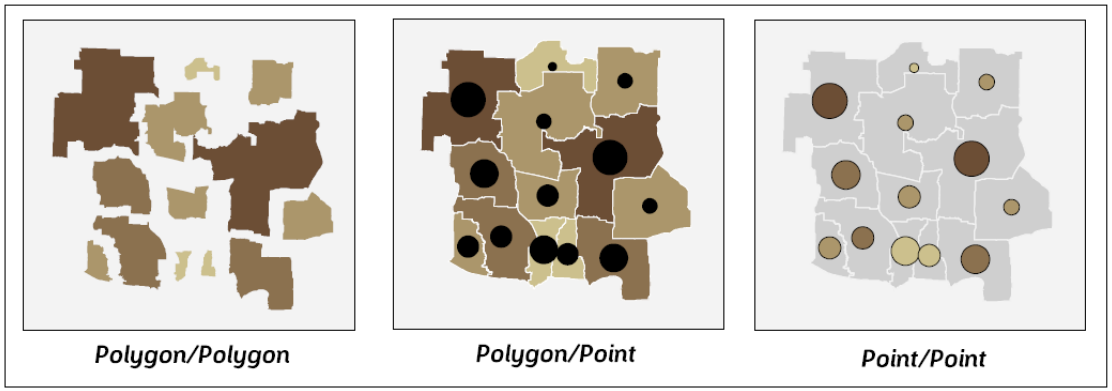
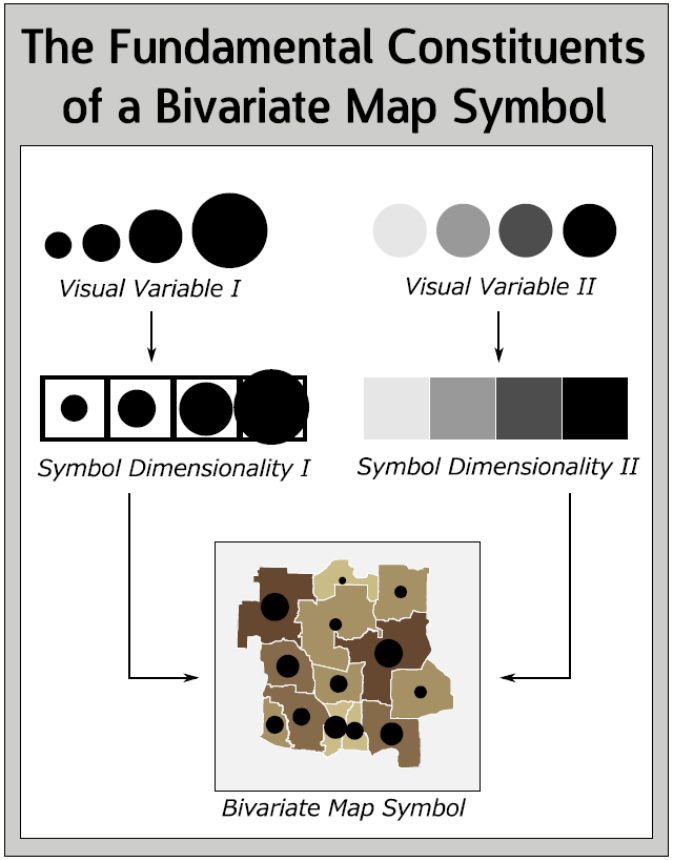


Fig. 494. Cross-hatched Map on the Population Projection.

How Bivariate Maps Work

- By combining **2 visual variables** (size, shape, value…) and **2 symbol dimensionalities** (point, line, polygon…)





How Bivariate Maps Work

- We can create an exhaustive list of potential bivariate map symbols (some are more sensible than others…)

Polygon/Polygon Symbols

Size (Height/Width)	X							
Color (H/S/V)	***Shaded Cartogram***	***2-Axis Choropleth***						
Transparency	*Cartogram w/ VBA*	***VBA Map***	X					
Orientation	X	X	X	X				
Fill Size (H/W)	Shaded Cartogram*	2-Axis Choropleth*	X	X	Bivariate Texture			
Fill Color (H/S/V)	Cartogram w/ ST	Choropleth w/ ST	VBA w/ ST	X	ST w/ Texture	2-Axis Choropleth*		
Fill Density	*Cartogram w/ Dot Density*	***Choropleth w/ Dot Density***	VBA w/ Dot Dens.	X	Graduated Dot Dens.	Shaded Dot Dens.	2 series Dot Dens.	
Fill Orientation	Cartogram w/ Rotated Texture	Choropleth w/ Rotated Texture	VBA w/ Rotating Texture	X	Bivariate Texture	Bivariate Texture	Bivariate Texture	X
	Size (Height/Width)	**Color (H/S/V)**	**Transparency**	**Orientation**	**Fill Size (H/W)**	**Fill Color (H/S/V)**	**Fill Density**	**Fill Orientation**

Polygon/Point Symbols

Size (Height/Width)	***Cartogram w/ Grad. Symb***							
Color (H/S/V)	***Choropleth w/ Grad. Symb***	Choropleth w/ Shaded Symb						
Transparency	*VBA w/ Grad. Symb*	VBA w/ Shaded Symb	VBA w/ VBA Symb.					
Orientation	Cartogram w/ Symb.	Choropleth w/ Symb.	VBA w/ Rotated Symb.	X				
Fill Size (H/W)	Cartogram w/ Shaded Symb*	Choropleth w/ Shaded Symb*	Choropleth w/ VBA Symb*	Chorop. W/ Rotated Symb.	Chorop. W/ Shaded Symb.			
Fill Color (H/S/V)	Shaded Text. W/ Grad Symb*	Shaded Text. W/ Shaded Symb.	Shaded Text. W/ VBA Symb.	Shaded Text. W/ Rotated Symb.	X	X		
Fill Density	Dot Density w/ Shaded Symb.	Dot Density w/ Grad. Symb.	Dot Density with VBA Symb.	Dot Density w/ Rotated Symb.	X	X	X	
Fill Orientation	Rotated Texture w/ Grad. Symb.	Rotated Text. W/ Choro. Symb.	Rotated Text. W/ VBA Symb.	Rotated Text. W/ Rotated Symb.	X	X	X	X
	Size (Height/Width)	**Color (H/S/V)**	**Transparency**	**Orientation**	**Fill Size (H/W)**	**Fill Color (H/S/V)**	**Fill Density**	**Fill Orientation**

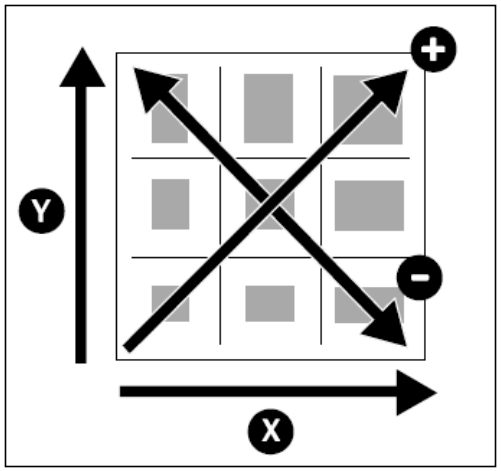
ST = Shaded T
VBA = Value b
* Functionally
X = untenable

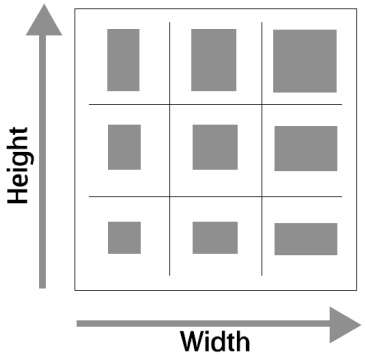
Point/Point Symbols

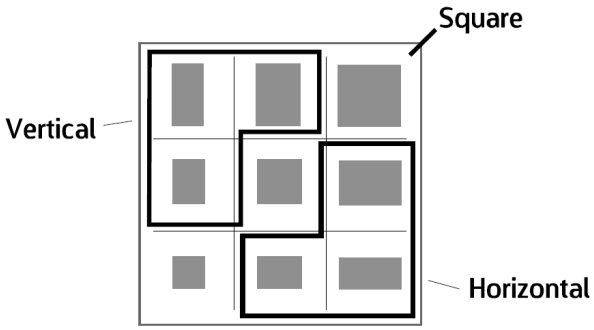
Size (Height/Width)	***Rectangle Map***							
Color (H/S/V)	***Graduated, Shaded Symbols***	*2-Axis Choropleth Symbols*						
Transparency	*Graduated, VBA Symbols*	*VBA Choropleth Symbols*	X					
Orientation	*Graduated, Rotated Symbols*	*Choropleth, Rotated Symbols*	*Rotated, VBA Symbols*	***Spoke Glyph***				
Fill Size (H/W)	X	X	X	X	X			
Fill Color (H/S/V)	X	X	X	X	X	X		
Fill Density	X	X	X	X	X	X	X	
Fill Orientation	X	X	X	X	X	X	X	X
	Size (Height/Width)	**Color (H/S/V)**	**Transparency**	**Orientation**	**Fill Size (H/W)**	**Fill Color (H/S/V)**	**Fill Density**	**Fill Orientation**

How Bivariate Maps Work

- All bivariate maps contain two **emergent visual variables** that encode the **relationship**.
- (The two additional information axes: **+ and -**)



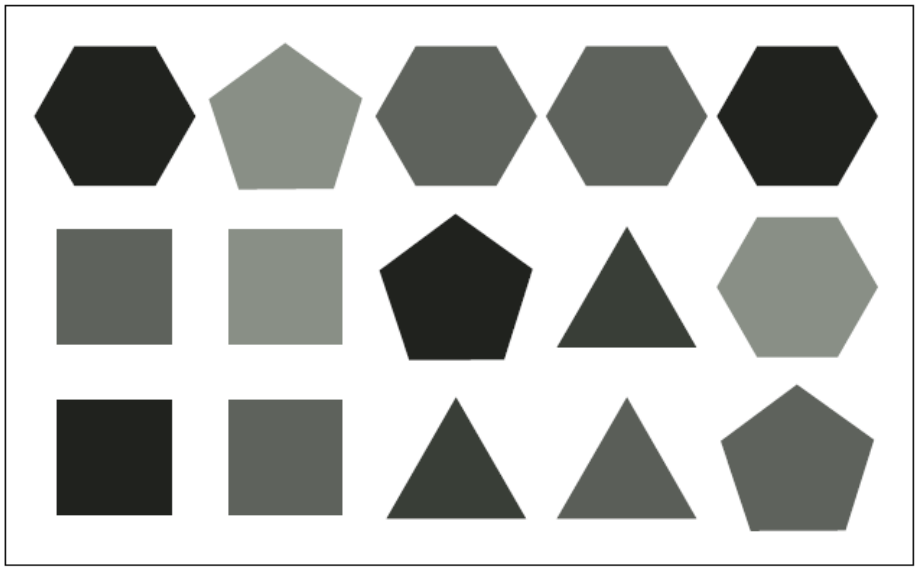




Bivariate Maps and Selective Attention

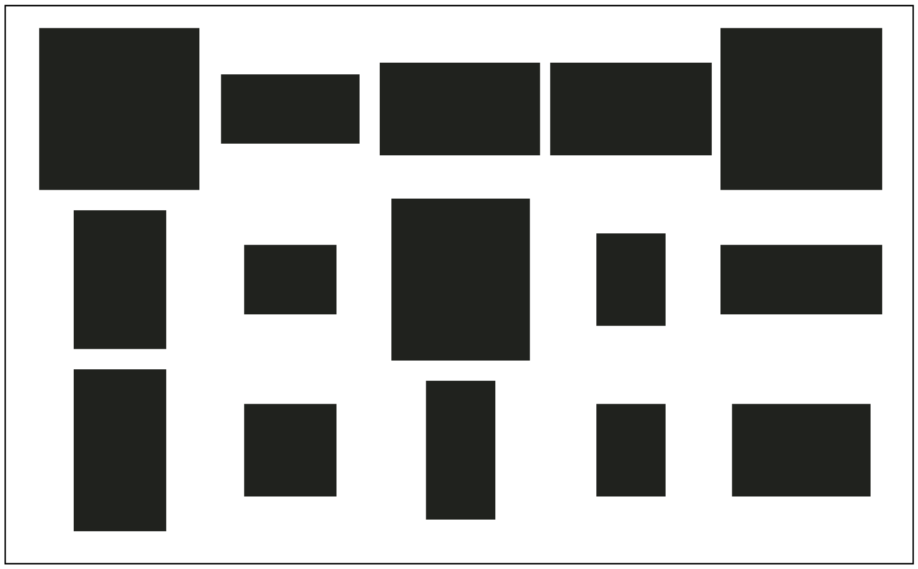
- **Selective Attention** : the superpower to 'tune in' & 'tune out' stimuli

Bivariate Maps and Selective Attention



Seperable
Value/Shape

- **Good**: parsing individual distributions (find all dark shapes)
- **Bad**: parsing their relationship (find the black hexagons)

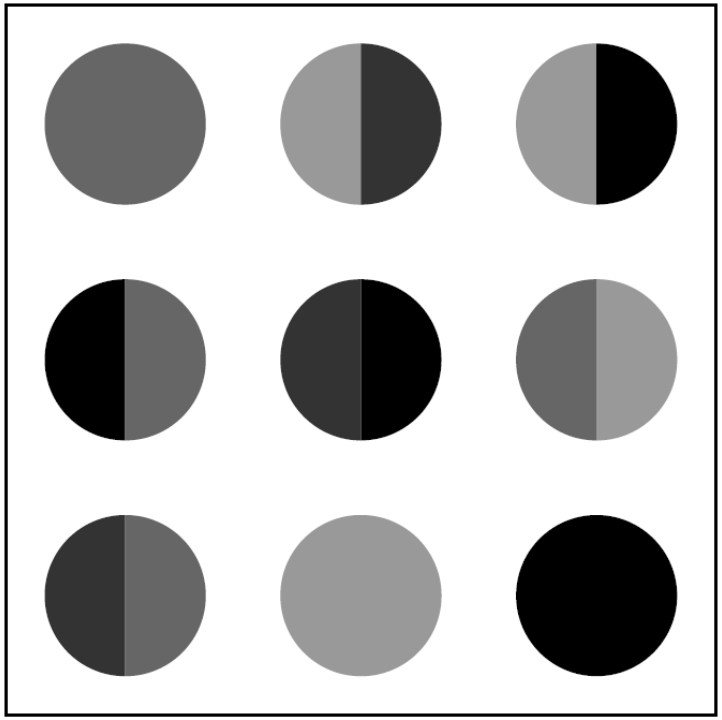


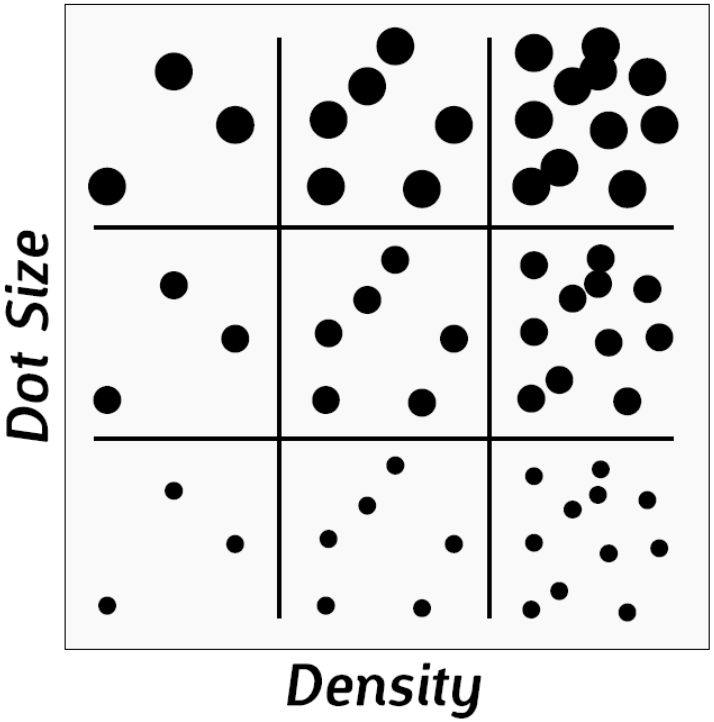
Integral
Height/Width

- **Good**: parsing relationships (find the small rectangles)
- **Bad**: parsing their individual distributions (find the equally wide rectangles)

Bivariate Maps and Selective Attention

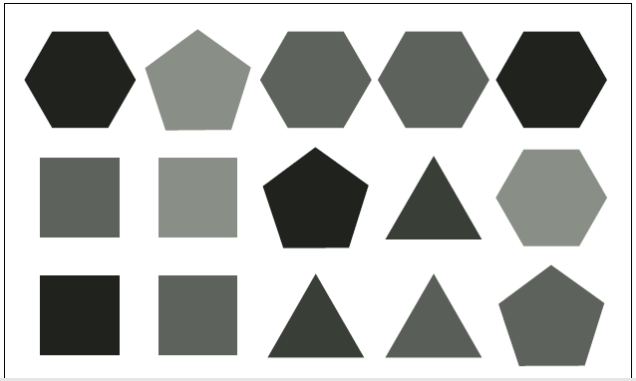
- **Configural** & **Asymmetrical** : somewhere in between separable & integral

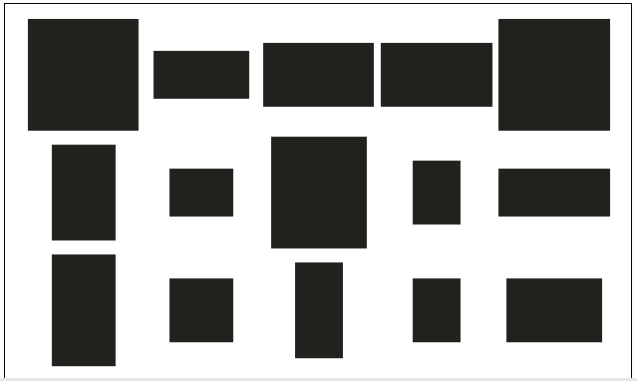


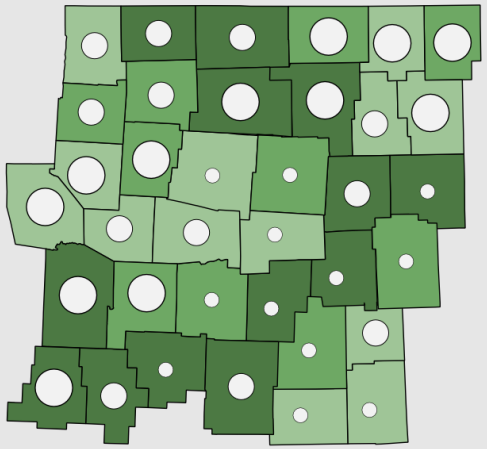


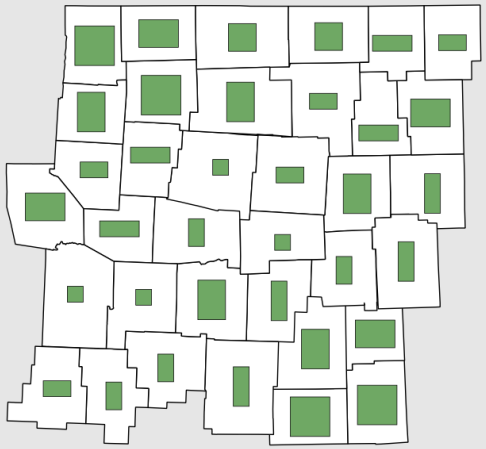
Bivariate Maps and Selective Attention

- The relevance to bivariate maps is obvious, but...



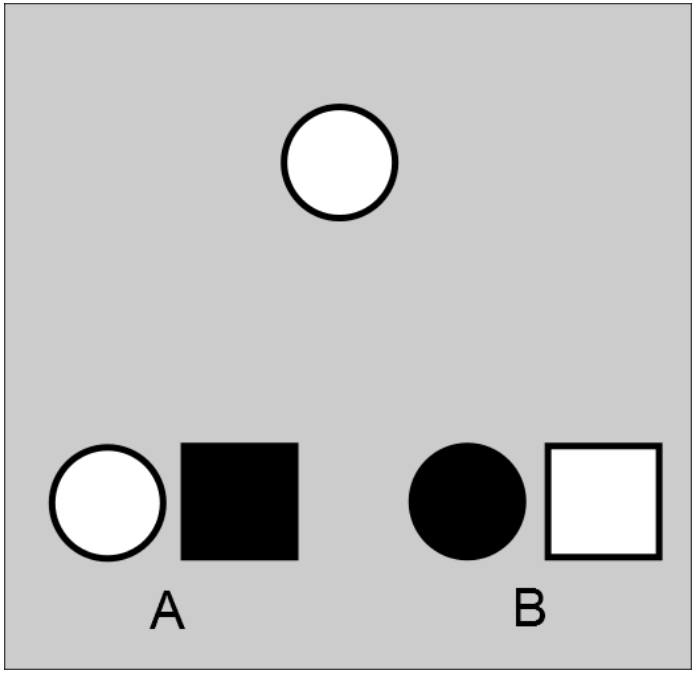


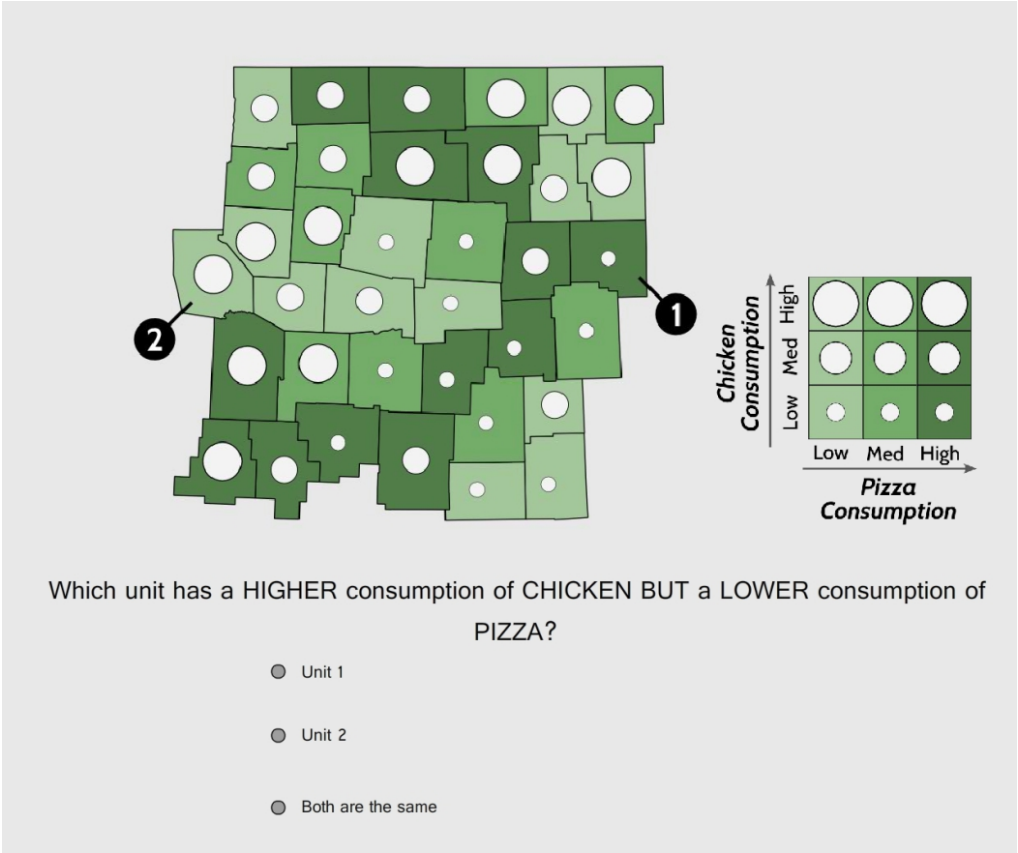




Bivariate Maps and Selective Attention

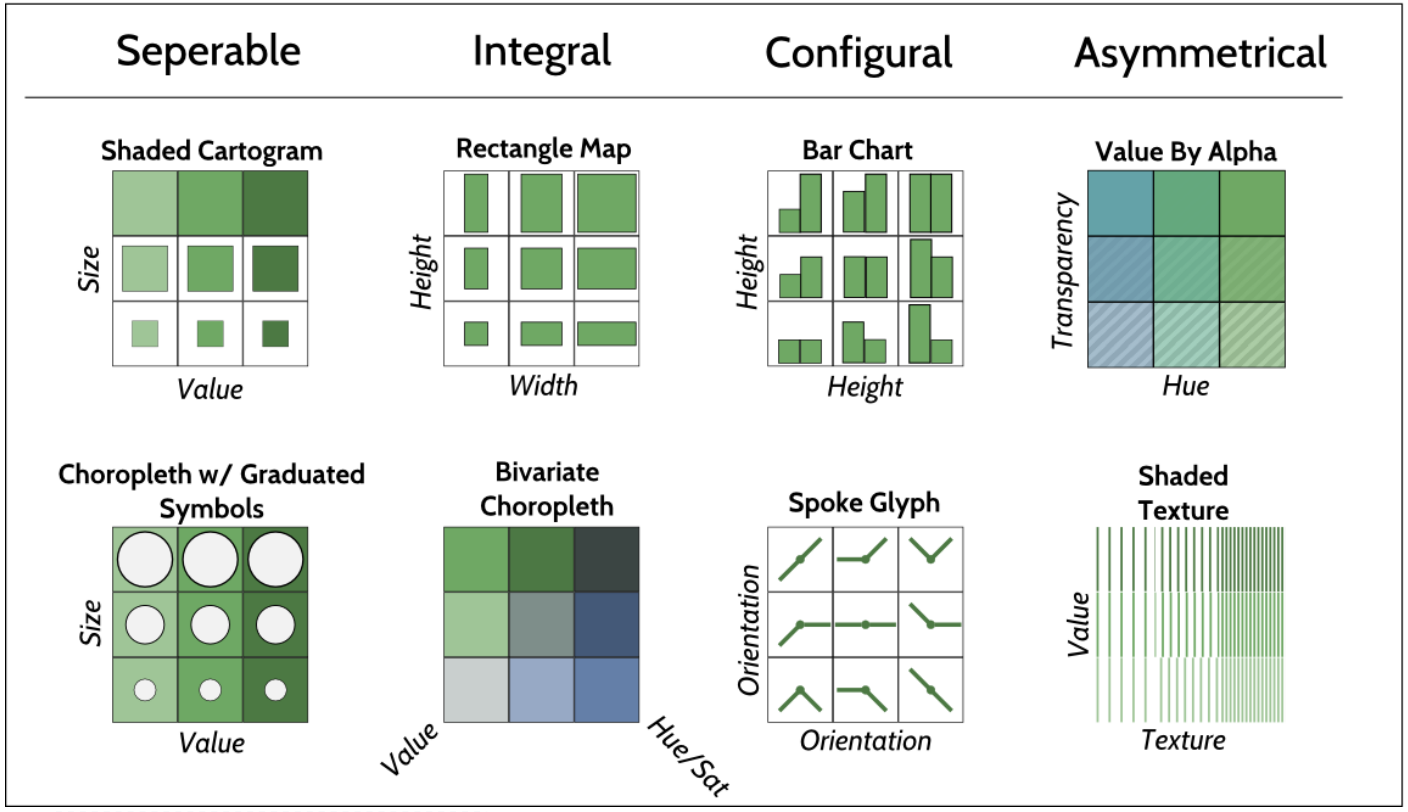
- **Speeded classification** is very different from **map reading**

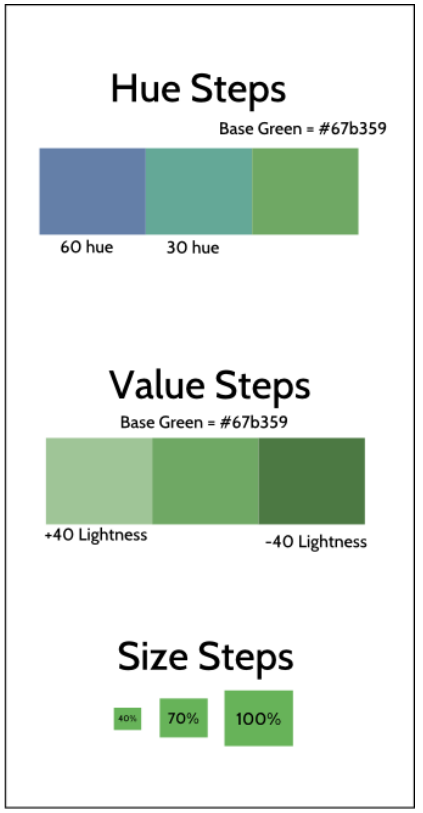




An Empirical Study on Bivariate Maps

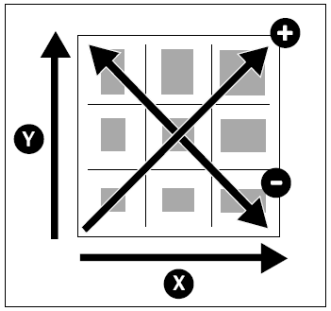
- Performance testing 8 bivariate maps
- (2 from each form of selectivity)

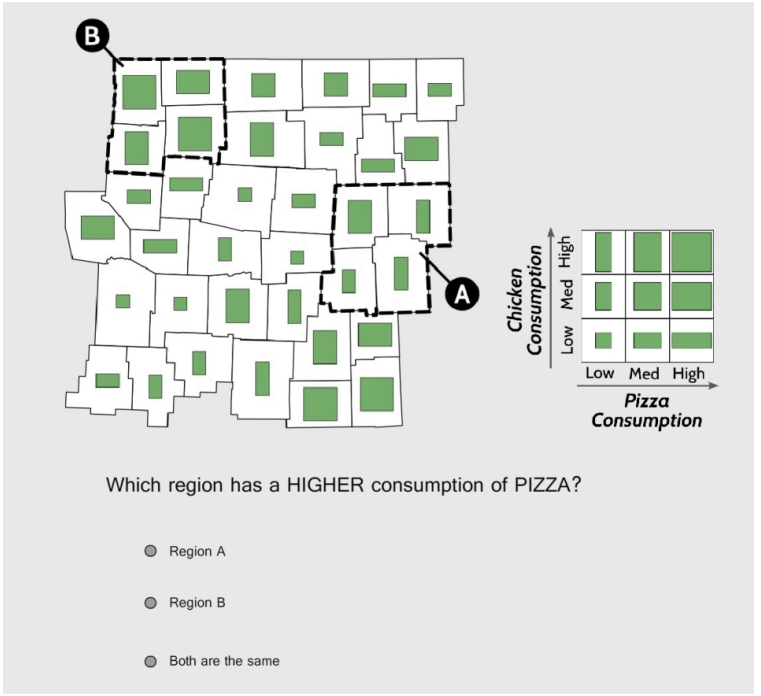




An Empirical Study on Bivariate Maps

- Compare two areas that fall along the four axes:
  - **X**: high X *vs* low X
  - **Y**: high Y *vs* low Y
  - **+**: Both high *vs* both low
  - **-**: Y>X *vs* X>Y

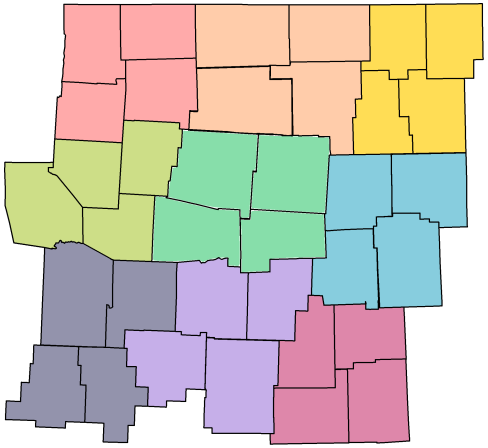


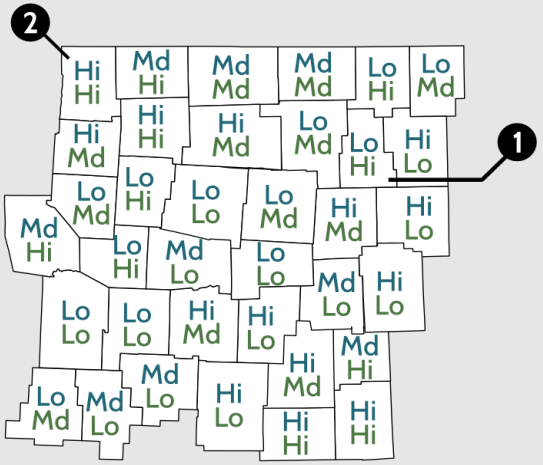


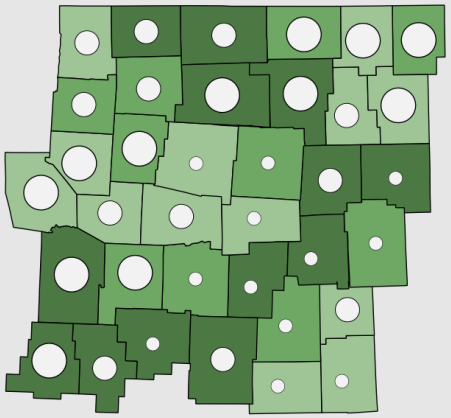
- At both *elementary* (1 unit) and *general* (multiple units) levels

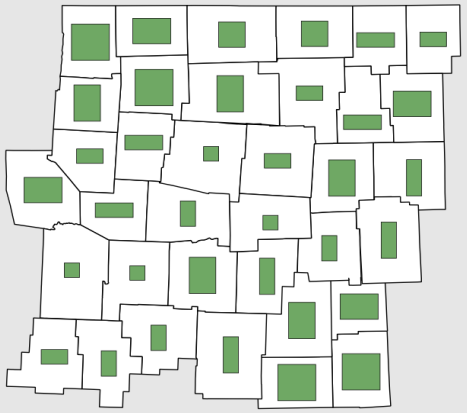
An Empirical Study on Bivariate Maps

- Notes on balancing (*it was a doozy*)









An Empirical Study on Bivariate Maps

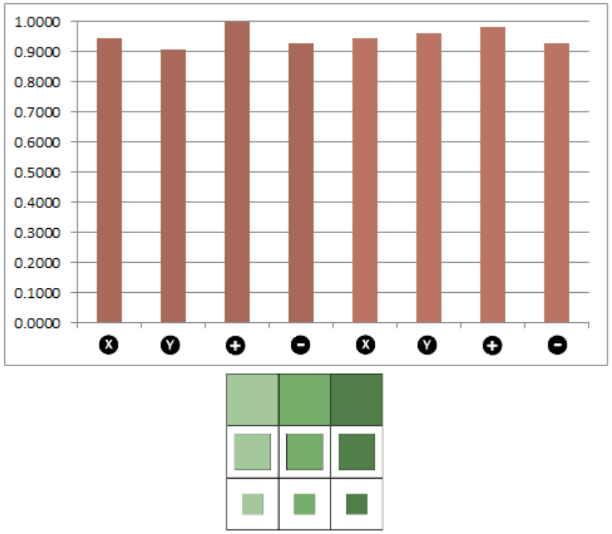
- n = 55
- **Accuracy** and **Reaction Time** collected
- Also: info on **Expertise** (30 undergrads problem)
- And an **Outro survey**:
  - Visually Displeasing ↔ Visually Appealing
  - Hard to Read ↔ Easy to Read
  - etc

An Empirical Study on Bivariate Maps

(preliminary)

Results!

Accuracy


1.0000
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0.7000
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0.4000
0.3000
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X
Y
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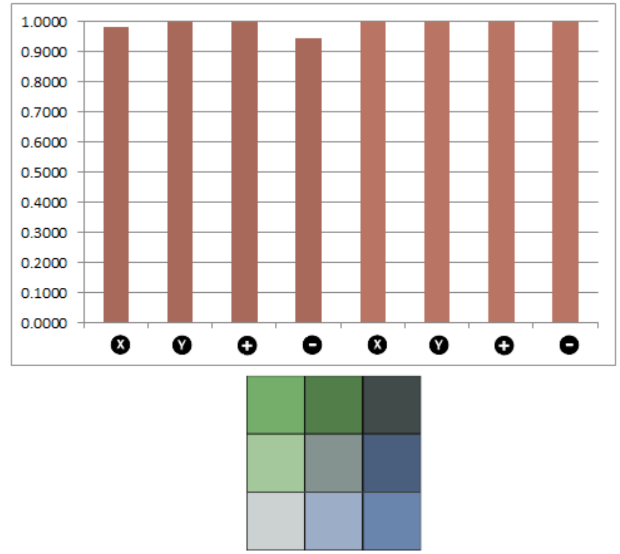
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0.5000
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0.3000
0.2000
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0.0000
X
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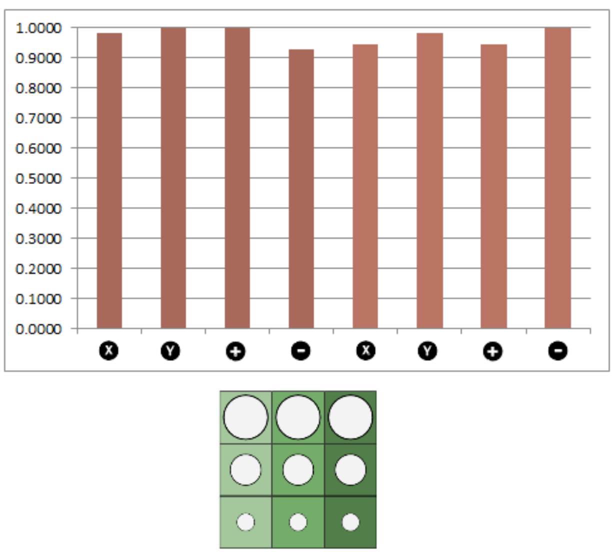
X
Y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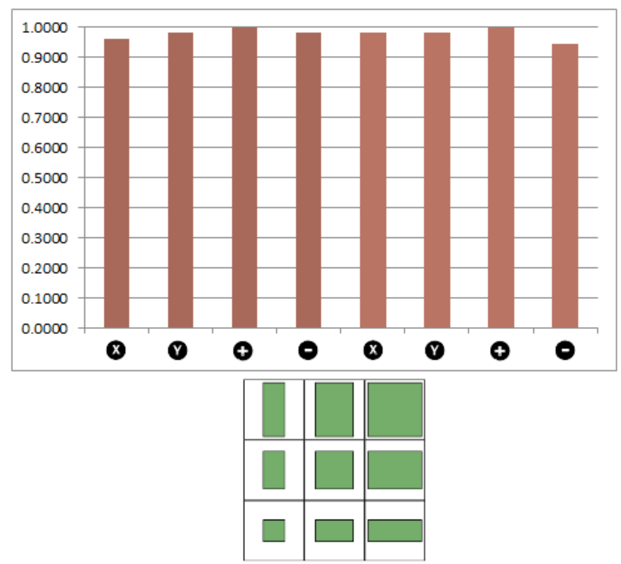
0.2000
0.1000
0.0000
X
Y
X
Y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0.9000
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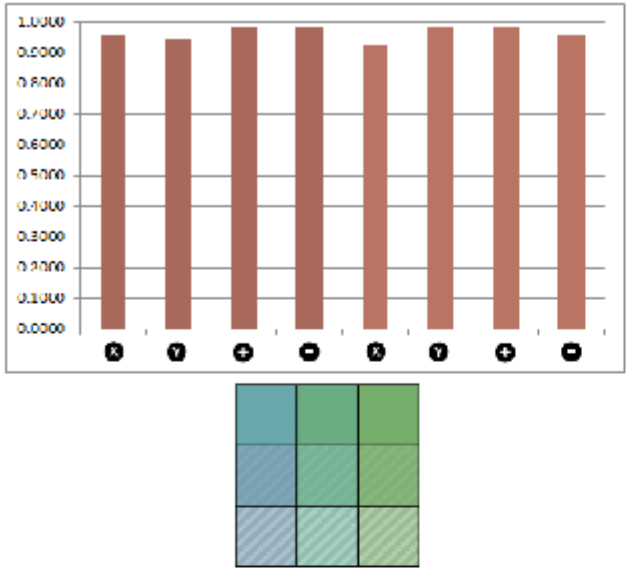
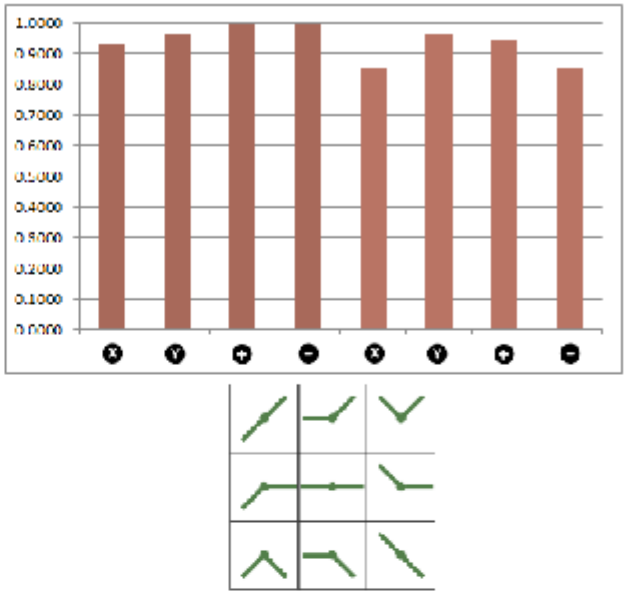
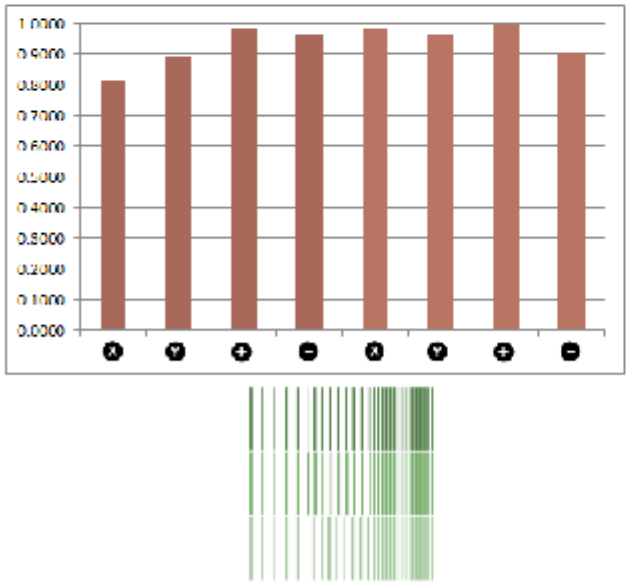
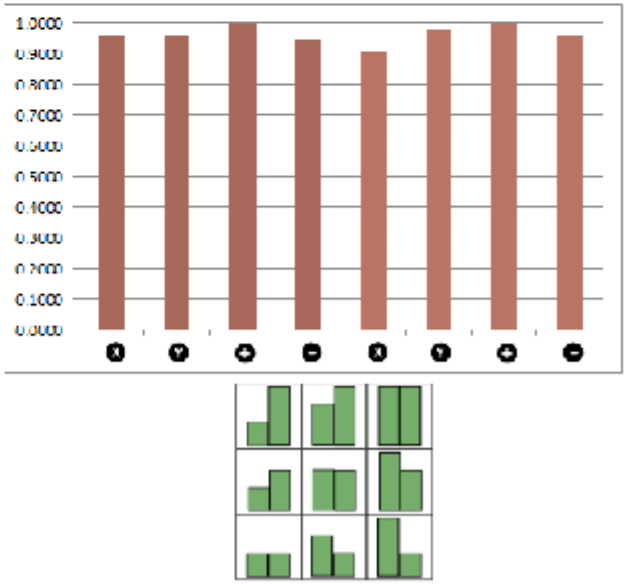
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
X
Y
X
Y

Accuracy



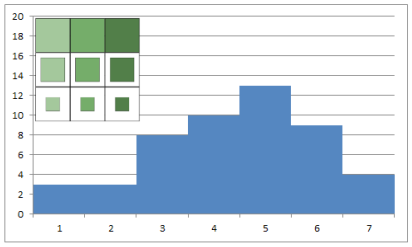




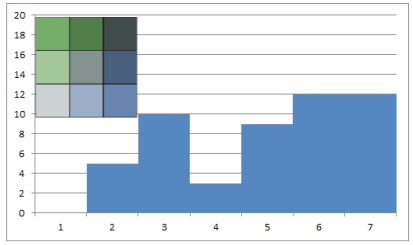


An Empirical Study on Bivariate Maps

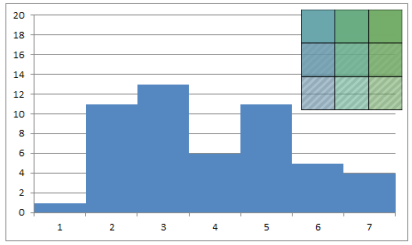
Difficult to Read <----> Easy to Read



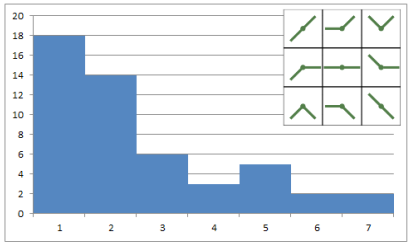
Separable



Integral



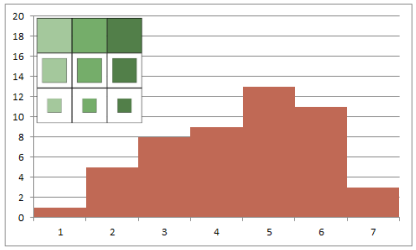
Asymmetrical

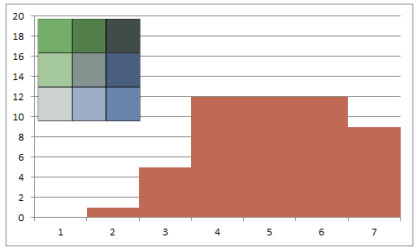


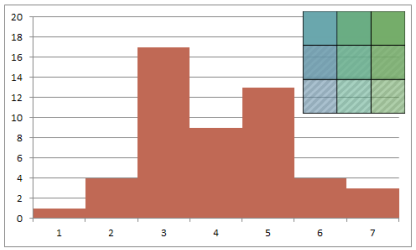
Configural

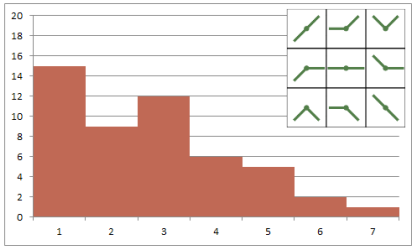
An Empirical Study on Bivariate Maps

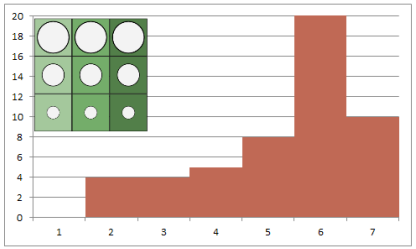
Bad Overall <---> Good Overall

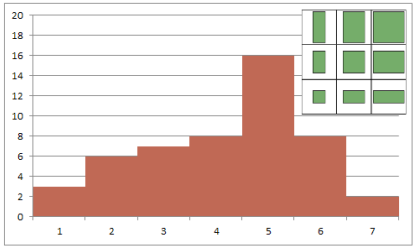


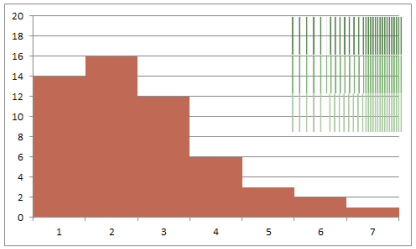


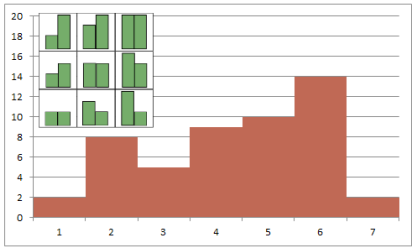






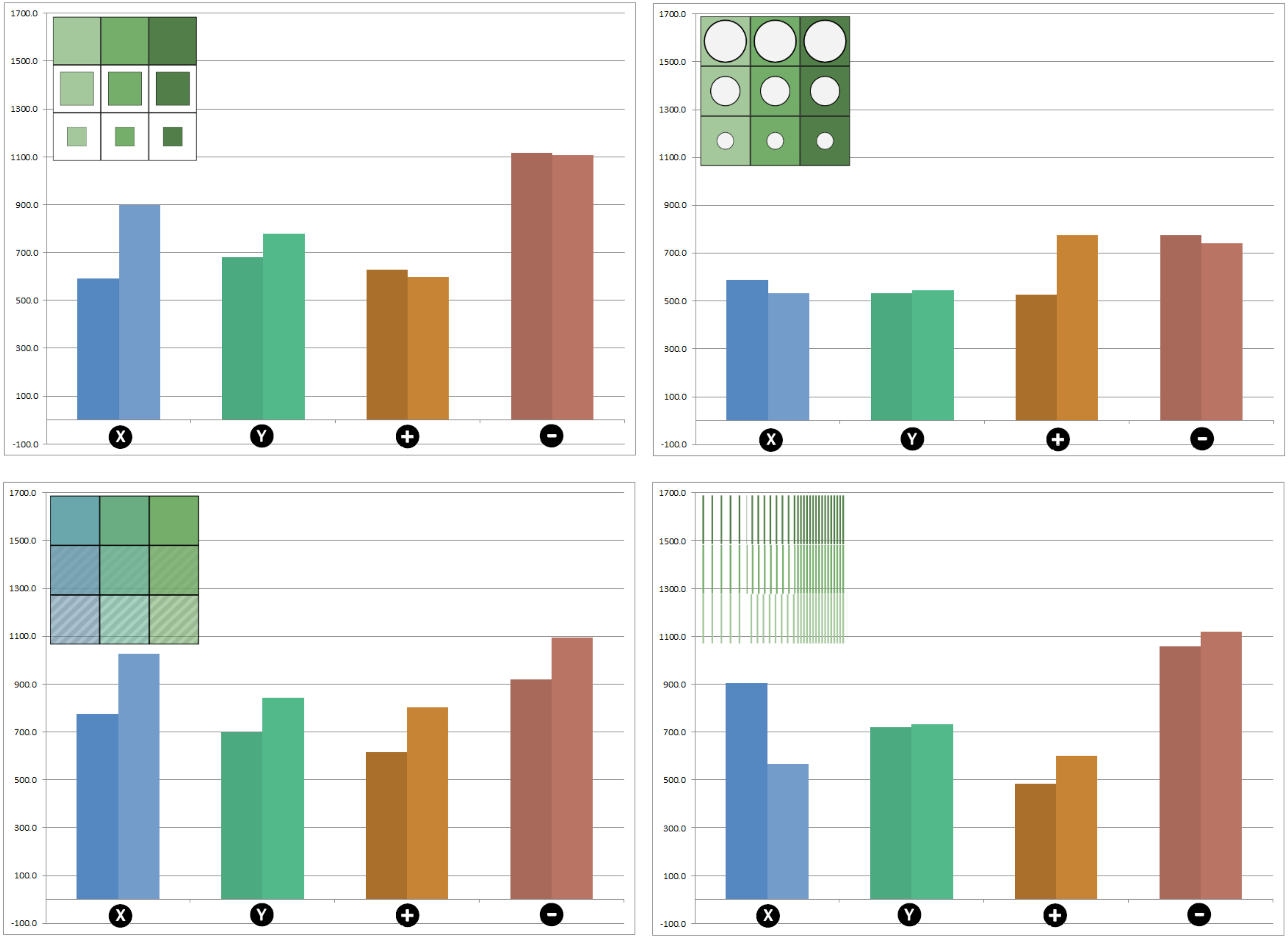




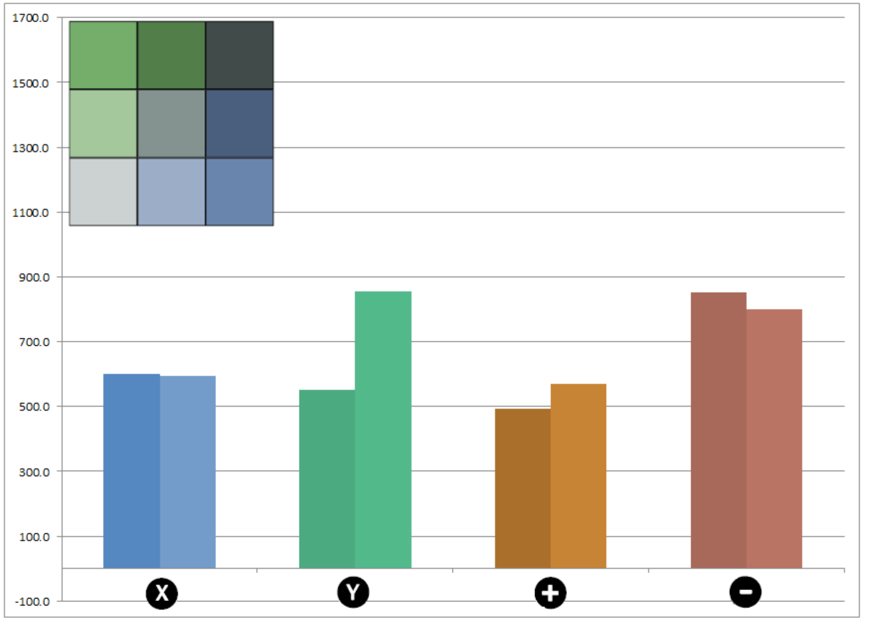


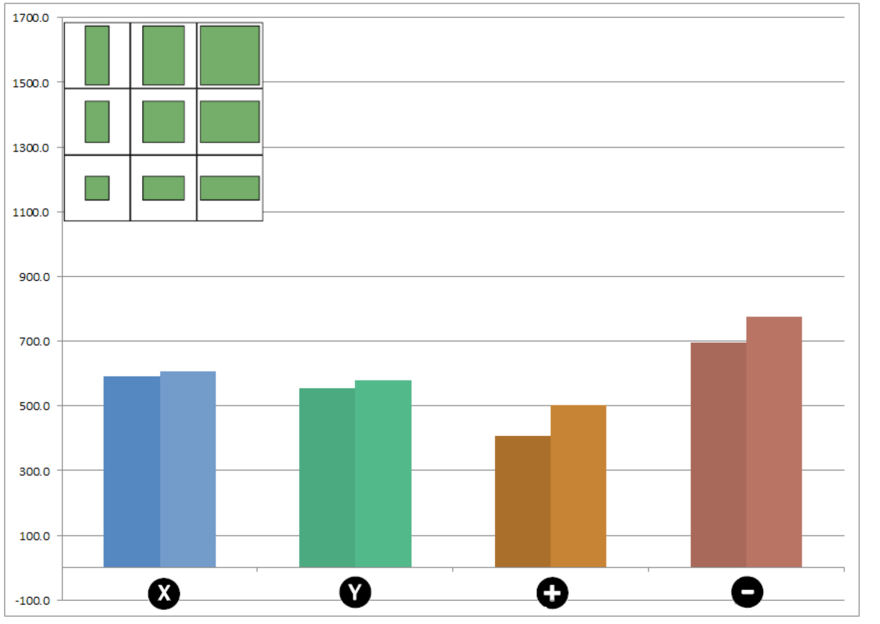
Separable *Integral* *Asymmetrical* *Configural*

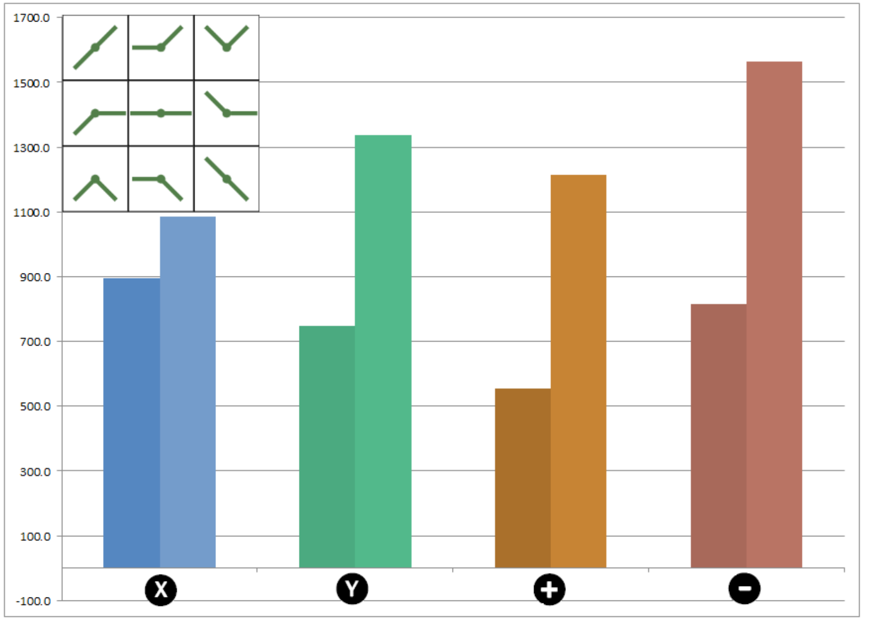
▶ Reaction Times

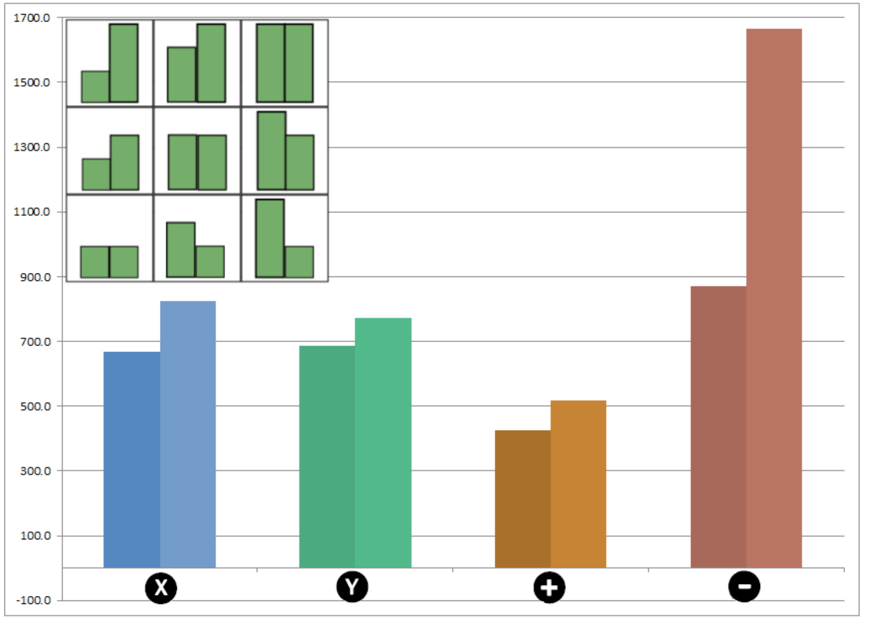


Reaction Times









Thanks!

- *Special Thanks:*
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