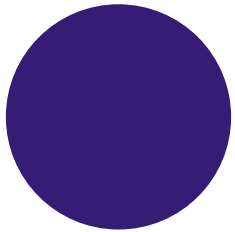
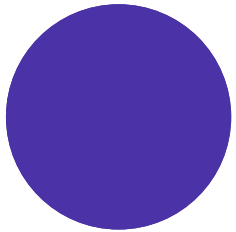
Modeling Color Difference for Visualization Design

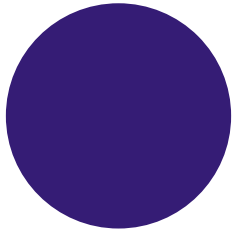
Danielle Albers Szafir

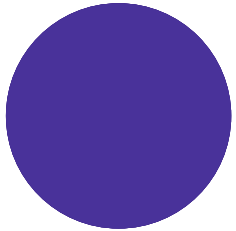
Proc. InfoVis 2017

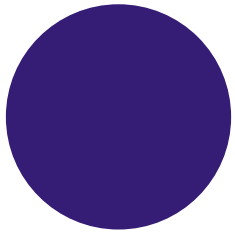
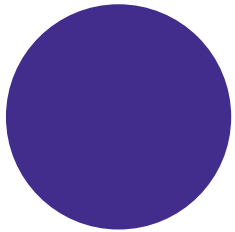
Are the colours the **same** or **different**?

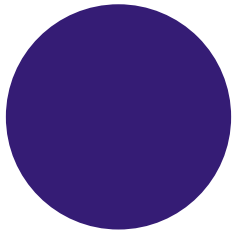
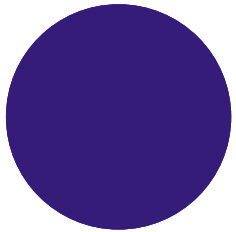


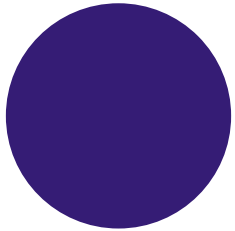
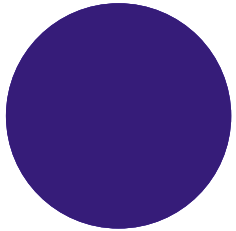






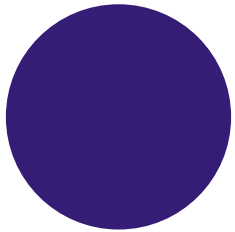



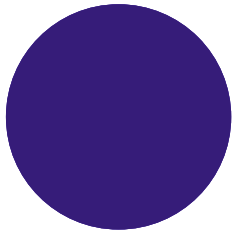



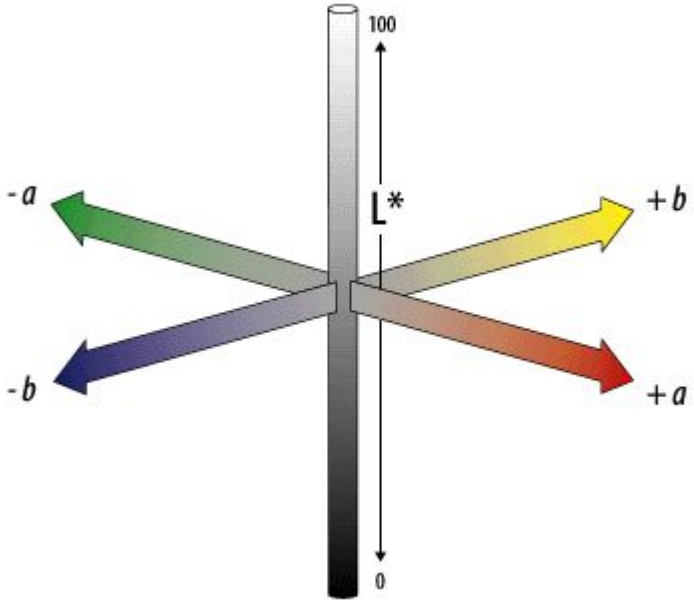
Just noticeable differences (JNDs)

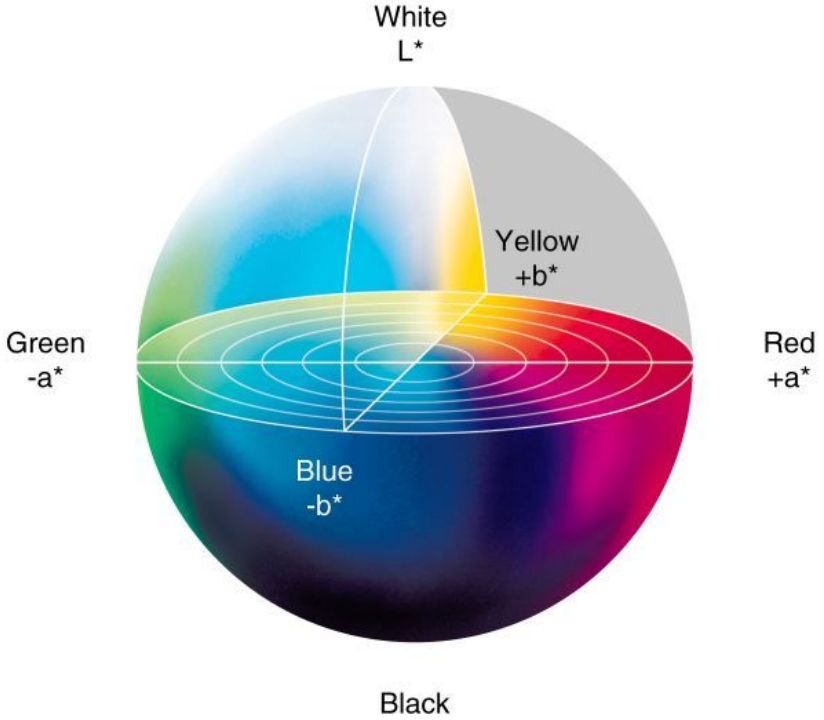
the point at which we can notice the difference 50% of the time



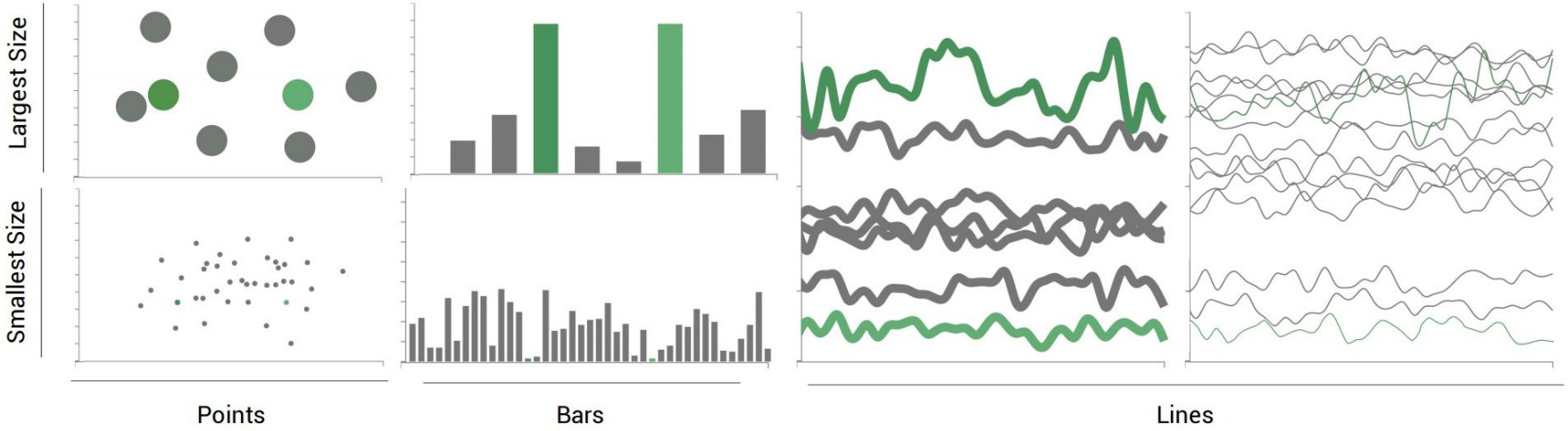


CIE L*A*B* colour space: perceptually equal steps





Visualizations are more complex



goal: build **qualitative understanding** of color perception in *visualization*

Assumptions

Simple World

Isolation

Geometric

Assumptions

Simple World

Isolation

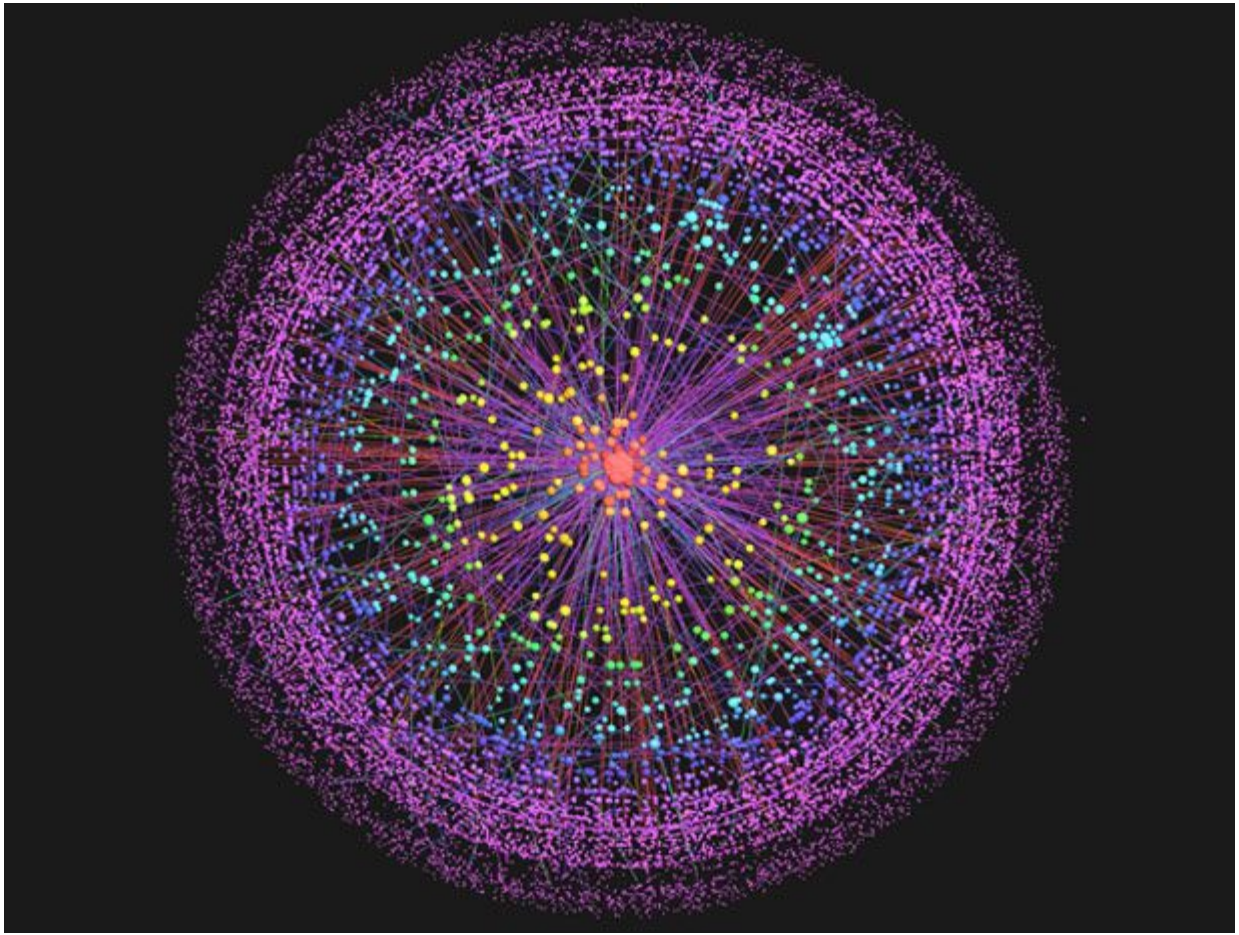
Geometric

Assumptions

Simple World

Isolation

Geometric



Solution

Simple World

Isolation

Geometric

crowdsource

Solution

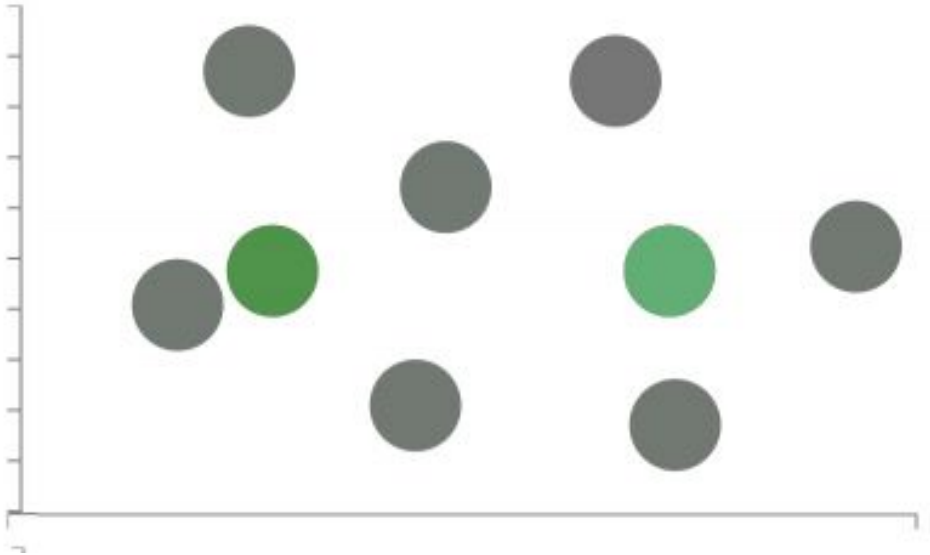
Simple World

Isolation

Geometric

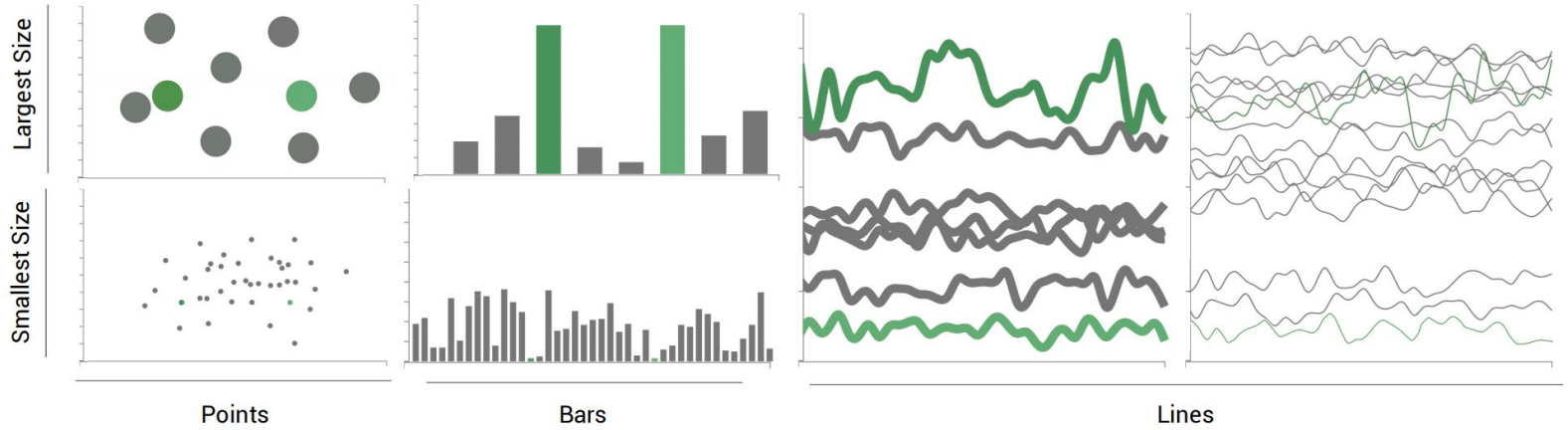
crowdsource

distractors

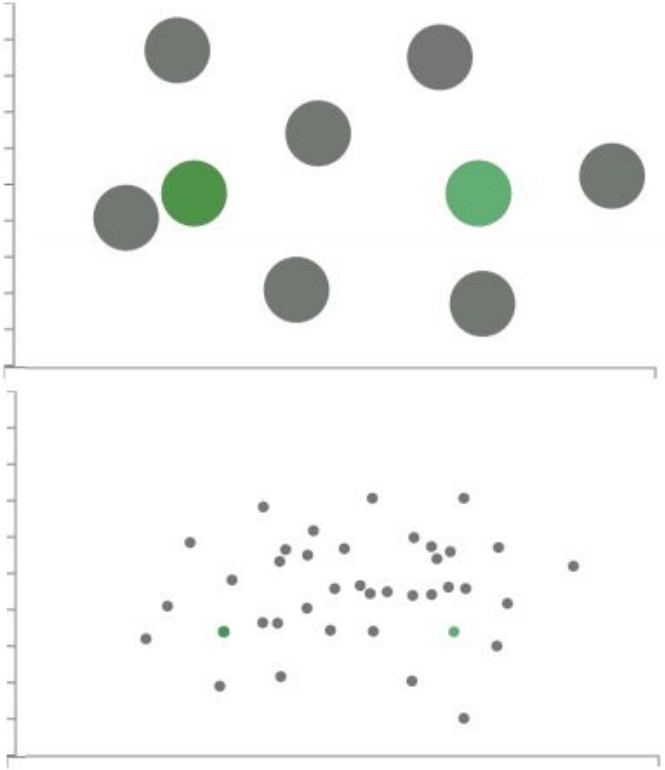


Solution

Simple World	**crowdsource**
Isolation	**distractors**
Geometric	**varied mark shape, size**



Scatterplots



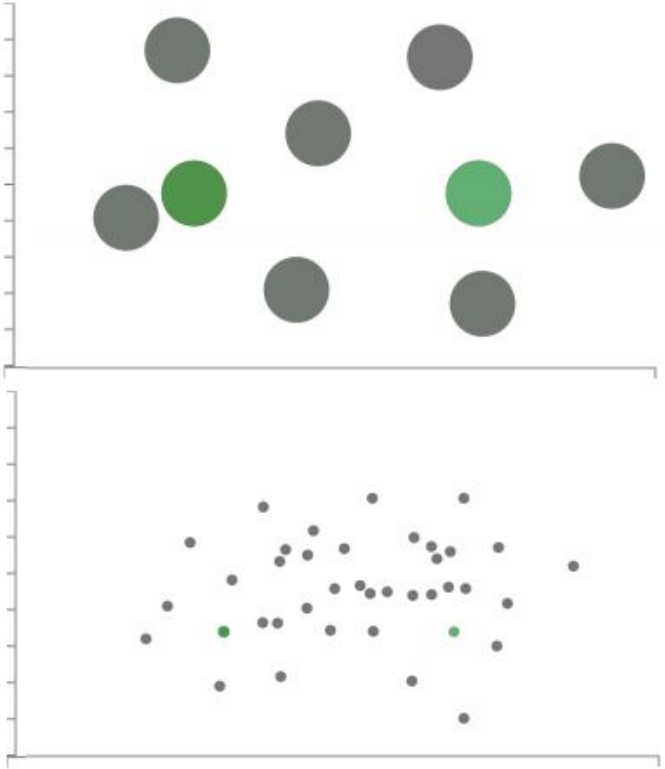
72 participants

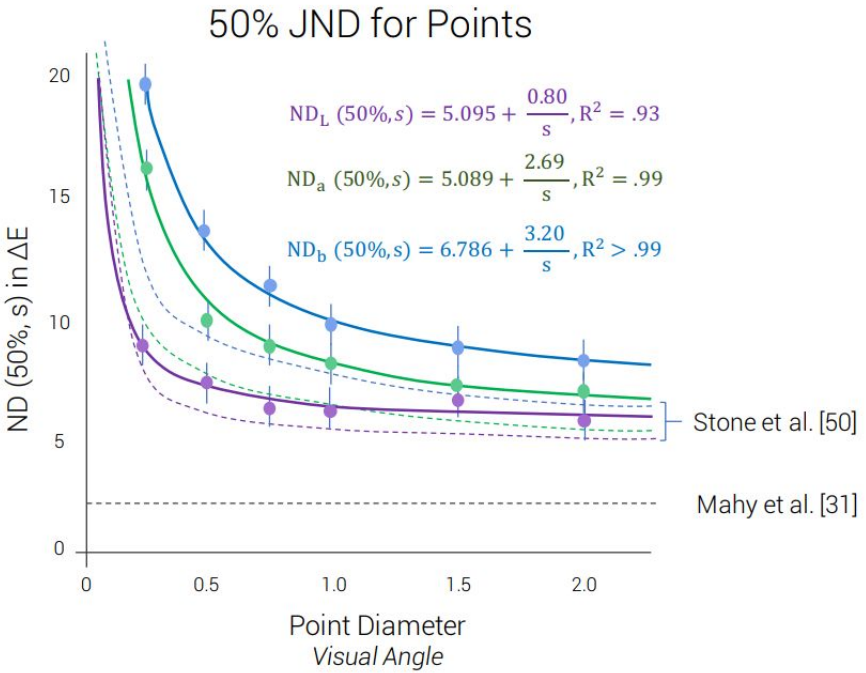
factors:

- 6 diameters ×
- 6 color differences ×
- 3 color axes

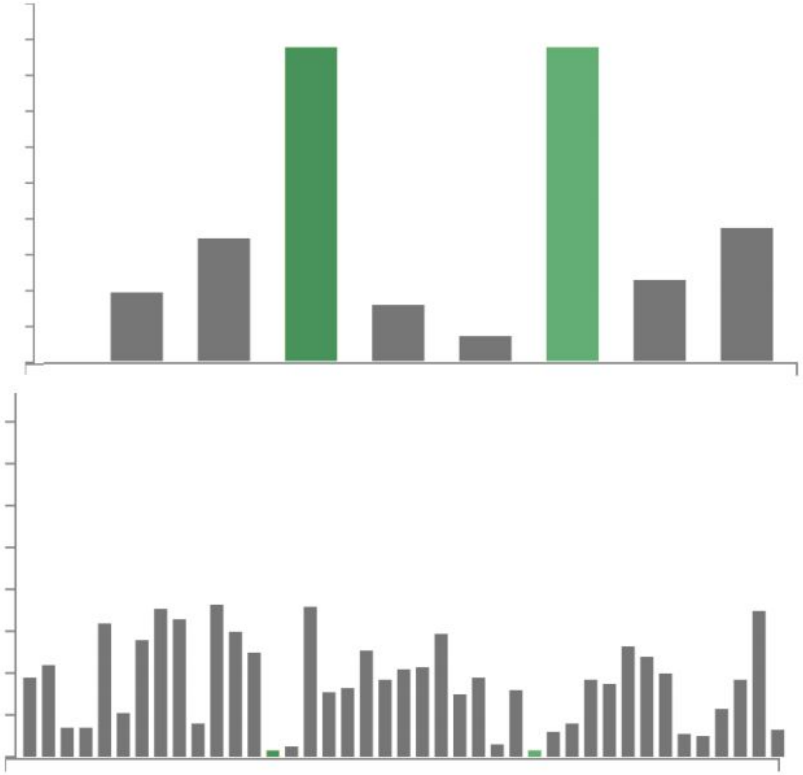
each participant saw each diameter × color difference twice

Scatterplots





Bar charts

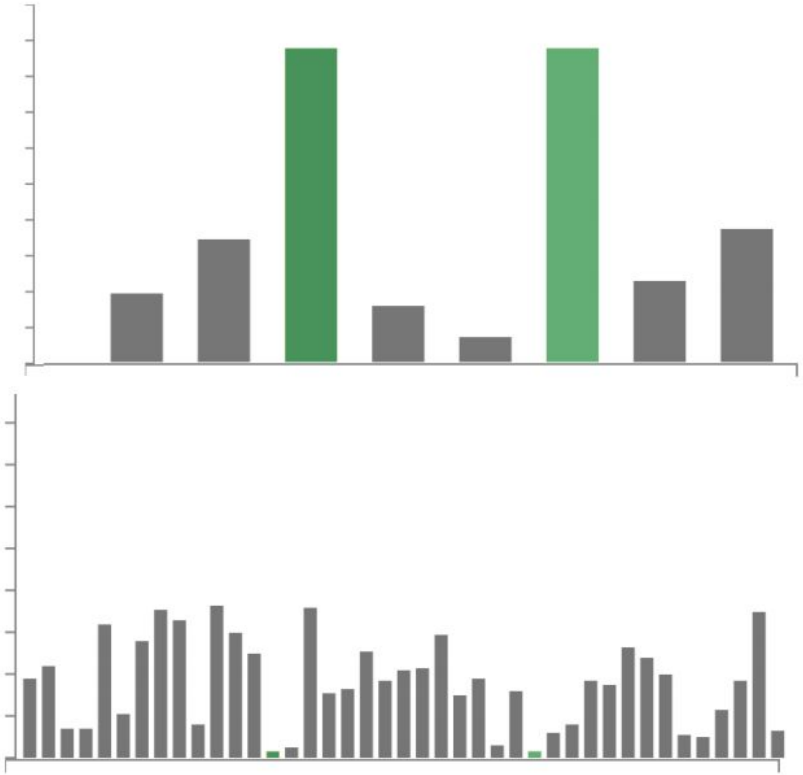


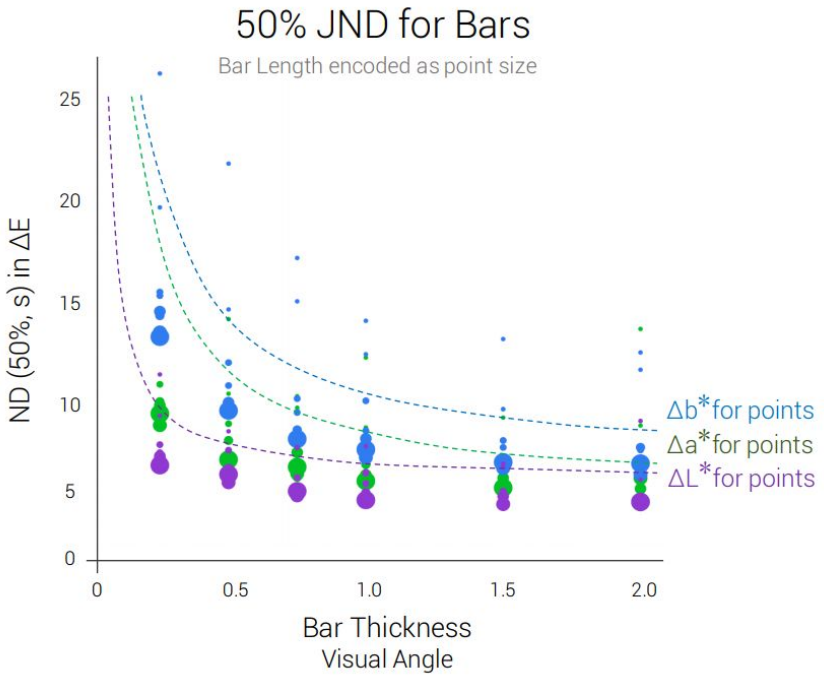
288 participants

factors:

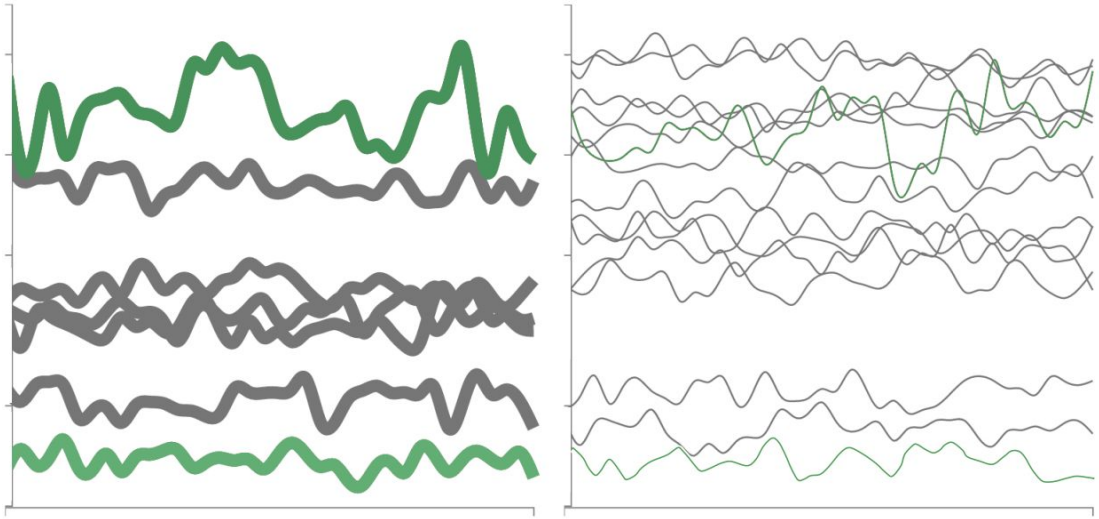
- 6 thicknesses ×
- 8 lengths
- 6 color differences ×
- 3 color axes

Bar charts




50% JND for Bars
Bar Length encoded as point size
ND (50%, s) in ΔE
25
20
15
10
5
0
0
0.5
1.0
1.5
2.0
Bar Thickness
Visual Angle
Δb*for points
Δa*for points
ΔL*for points

Line graphs

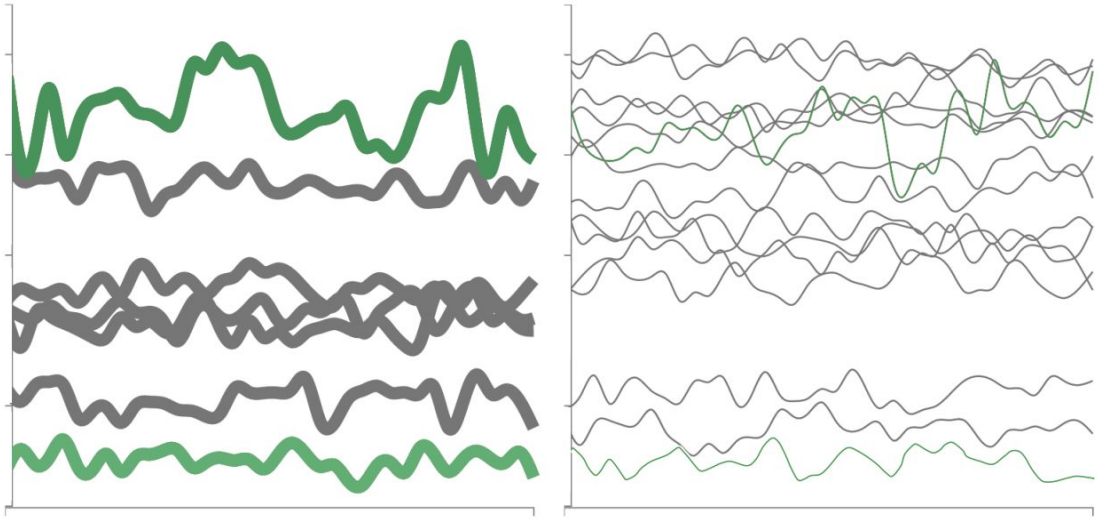


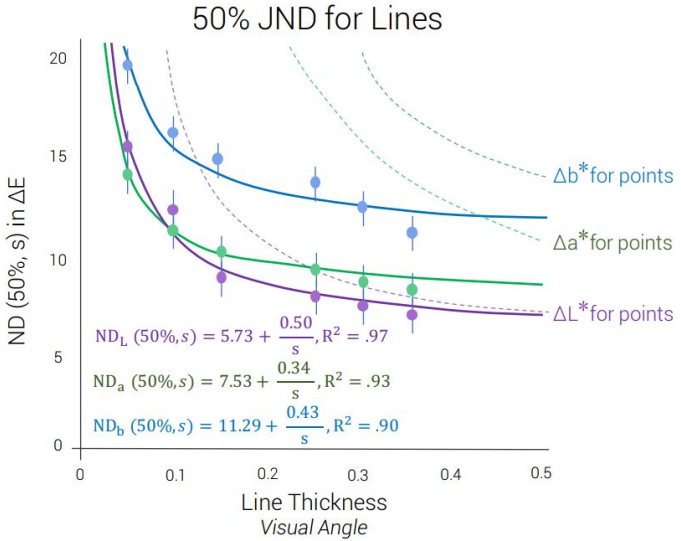
72 participants

factors:

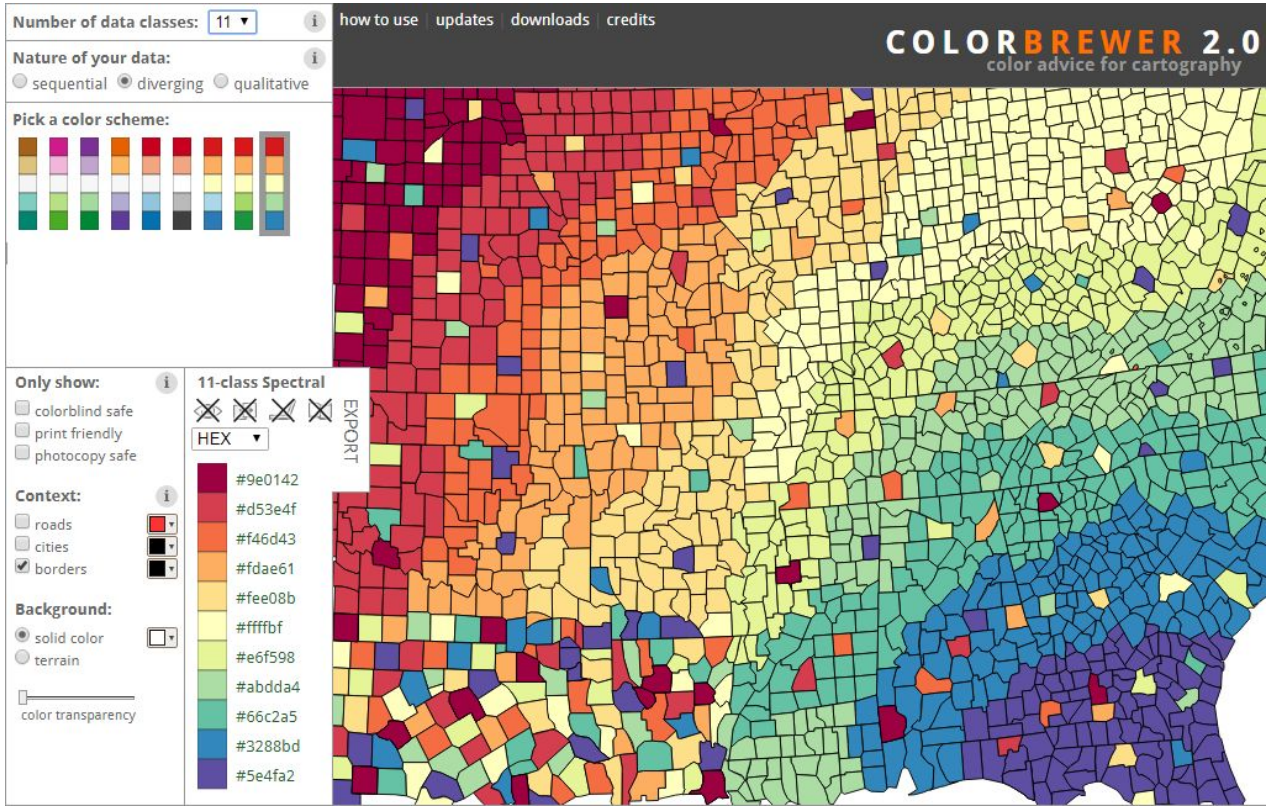
- 6 thicknesses ×
- 6 color differences ×
- 3 color axes

Line graphs



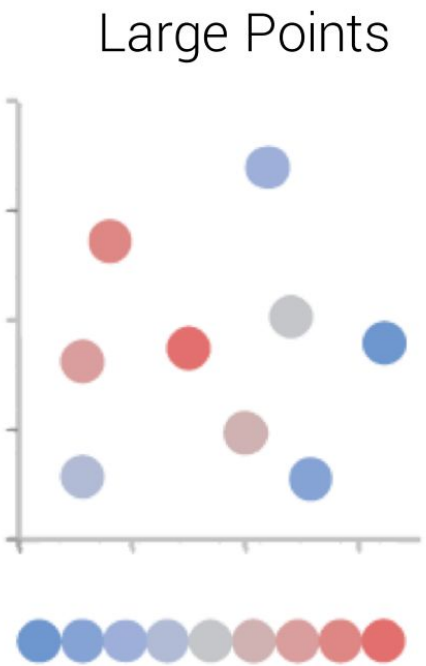

50% JND for Lines
ND (50%, s) in ΔE
20
15
10
5
0
0
0.1
0.2
0.3
0.4
0.5
Line Thickness
Visual Angle
Δb*for points
Δa*for points
ΔL*for points
$ND_L(50\%,s) = 5.73 + \frac{0.50}{s}, R^2 = .97$
$ND_a(50\%,s) = 7.53 + \frac{0.34}{s}, R^2 = .93$
$ND_b(50\%,s) = 11.29 + \frac{0.43}{s}, R^2 = .90$

ColorBrewer

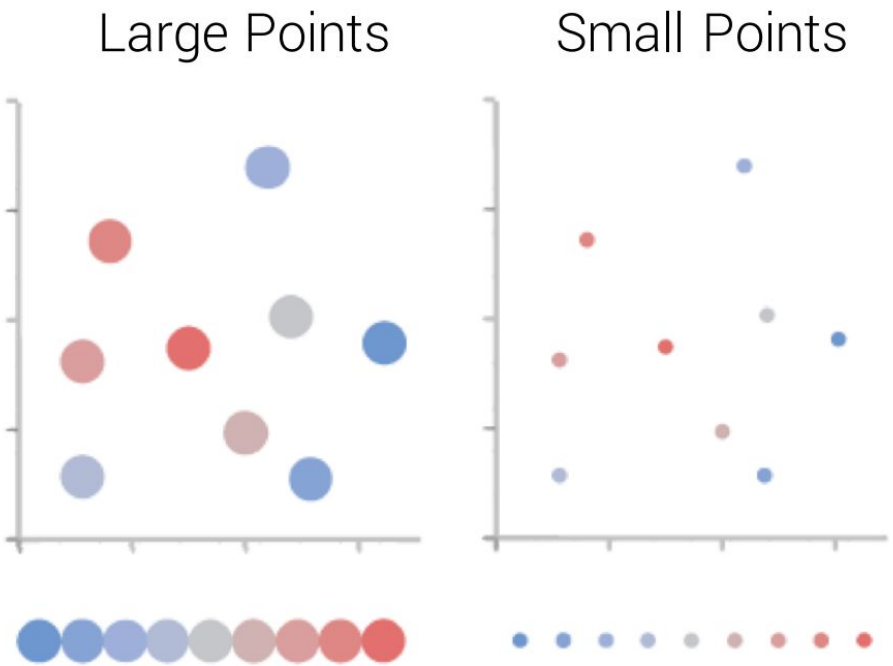


not robust to smaller mark sizes!

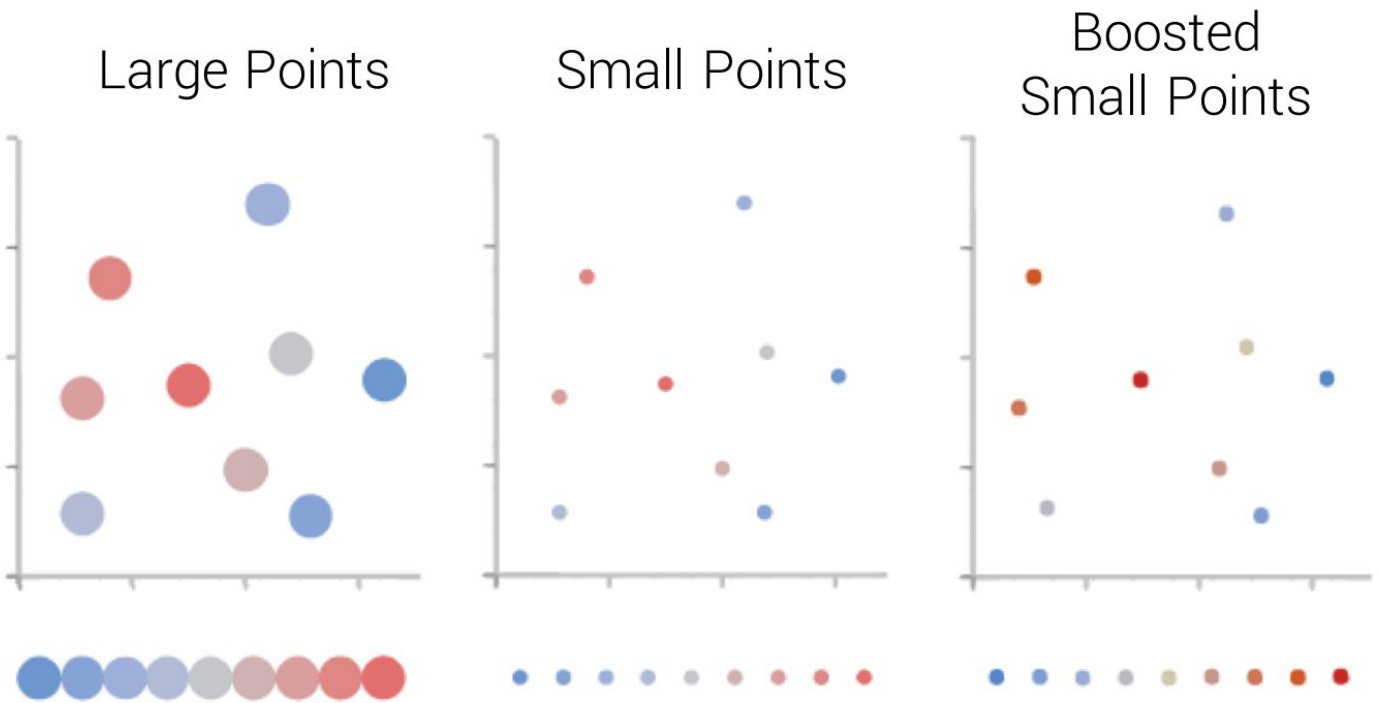
Applications



Applications



Applications



Limitations

Author:

- only two marks were coloured - contrast differences absent
- marks tested at fixed distances and aligned

Limitations

Author:

- only two marks were coloured - contrast differences absent
- marks tested at fixed distances and aligned

Amon:

- colour distance ΔE in CIEL*a*b* space is non-uniform to begin with
- rather than overfit to CIEL*a*b*, start with a raw colour space
- staircase method to sample more data around JND

Thanks!

paper page: http://cmci.colorado.edu/visualab/VisColors/index.html