

Design Characterization for Black-and-White Textures in Visualization

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Black-and-white textures in 20th century visualization



Images from J. Bertin, Semiology of Graphics: Diagrams, Networks, Maps, and W. C. Brinton, Graphic Methods for Presenting Facts



Improve visualizations' accessibility



Devices with limited color display capabilities

Images from https://fr.moviles.com/lenovo/vibe-band-vb10, https://www.tactplusprinter.com/about; Icons from https://icons8.com/





Users with visual impairments



Effective for encoding nominal data

Quantitative

Ordi

Position Positi Length Densi Color Angle Slope Color Area Textu Volume Conn Density Conta **Color Saturation** Lengt Color Hue Angle Texture Slope Connection Area Volun Containment Shape Shape

Effectiveness of visual channels [Mackinlay, 1986]

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Popularity in history



Lack of empirical research on the use of b/w textures in visualization

Potential benefits





Rich attributes for encoding data







If textures are used improperly...

- Vibratory effect
- Visual clutter
- Unappealing aesthetics



. . .





Image from E. R. Tufte, The Visual Display of Quantitative Information.



for categorical data visualization?

How to **aesthetically** and **effectively** use black-and white textures





properties \ primitives	point-based	line-based	grid-based
shape type	• • • 0 0 0 • • • 0 0 0 • • • 0 0 0		\sim
density	• • • • • • • • • • • • • • •		
shape size			
orientation			₩X
background color			
randomness			

Step 1 Summarize important texture attributes for visualization

Carros C 0° 90° 180° 270° 360°

Step 2

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
This visualization is appealing.							
This visualization is pleasing .							
This visualization is enjoyable.							
This visualization is likable.							
This visualization is nice.							
This visualization has a vibratory effect.							

Step 3 Crowdsourced experiment: visual appearance



Step 4 Crowdsourced experiment: effectiveness

Collect good texture designs for visualizations from experts



Summarize of texture attributes

properties \ prim	itives point
shape type	
density	• • • • • • • • •
shape size	
orientation	• • • • • • • • • • • • • • • •
background color	
randomness)



Primitives: Simple shapes or figurative icons

Here and the second sec



Iconic textures



Geometric textures

Texture design interface

- Need high-quality texture designs
 - Invite visualization design experts
- No existing design tool for easily adjusting and testing all texture parameters within different datasets in charts
 - Developed a texture design interface



Our texture design interface

Exp 1: Collect 66 designs from 30 experts - 14 bar charts













Exp 1: Collect 66 designs from 30 experts - 30 pie charts































olive

eggplan











Exp 1: Collect 66 designs from 30 experts - 22 maps



Exp 1: Design goals and strategies

Goal

"Visual distinctness (distinct) and consistency (consistent) in design"

Geometric

"For the geometric textures, I was aiming for textures that were not too bold and had roughly equal weight (balance) while being clearly distinct (distinct)"

Iconic

"I changed the icon size to reflect what they represented. (association) Also I centered the icons made it so that a complete icon (complete_icon) appeared near the bottom."

Goal

In general, I tried to make all columns distinguishable(distinct) given they are placed so close to each other, and then following either the same style or a rhythm of styles (consistent).

Geometric

same style or a rhythm of styles(consistent)

"For the geometric one, I used non-orthodox grid for all and from left to right, I put an increment on each grid strike so that it forms a gradient pattern. Meanwhile all grids are tiled as if pointing at the next column, up or down, resulting a sense of waves. I didn't a second style other than the grid because that would disturb the melody of the graph reading. "

Iconic

"For the icon one, I found the given example makes it hard to distinguish(distinct) columns, so my general strategy is bring a rhythm of color density to the graph by putting a black background next to a white one, repeat and so on so forth. Then I chose black icons with a little more details for all white background bars, and white stoked icons for all black bars to balance the visual (balance). "

"Readable: [Clear]

- there should be no ambiguity as to what the icon represents => e.g keeping the details for the corn, choosing black background for light-colored vegetables, [association] slecting a rotation which wouldn't compromise the icon recognition while allowing maximum size (eg in their current design, the carrots / eggplants / celery should be placed using alternating gridlines so they wouldn't touch when turned at 45°)

- the 7 textures should be as distinct [Distinct] as possible (no ambiguity) => variations of angles and backgrounds

Distinguishability

Clarity

Semantic association

Visual appearance

Visual balance

Readability

Aesthetics

Experiment 2

How does the general public perceive textures in terms of their **visual appearance**?

Exp 2: Stimuli

- 24 designs: 4 of each combination of texture type and chart type
- Representing a diverse range of aesthetic styles

- 150 participants from Prolific
- Rate 8 designs of a specific chart type (bar, pie, or map)

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- Rate 8 designs of a specific chart type
 - Aesthetics: BeauVis scale [He et al., 2023]
 - Vibratory effect

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
This visualization is appealing .	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
This visualization is pleasing.	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
This visualization is enjoyable.	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
This visualization is likable.	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
This visualization is nice .	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
isualization has a vibratory effect.	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc

Experient 2 screenshot

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Experient 2 screenshot

- 150 participants from Prolific
- Rate 8 designs of a specific chart type
 - ▶ Aesthetics: BeauVis scale [He et al., 2023]
 - Vibratory effect
- Rank 4 designs of each texture type
 - Overall preference

Exp 2: Individual chart

- **BeauVis** score with distribution
- Number of times being ranked first for overall preference
- Vibratory effect score

Exp 2: Diverse preference among participants

Designs with lower average scores often had uniform rating distributions Each chart was ranked as the top choice by some participants

Exp 2: Compare geometric and iconic textures

Report sample means and pairwise mean differences with 95% Cls

Aesthetics BeauVis score

Icons from https://icons8.com/

Exp 2: Compare geometric and iconic textures

Geometric maps were perceived as more aesthetic than iconic maps

For bar and pie charts, there is no evidence of difference in aesthetic appeal between geometric and iconic textures

Exp 2: Compare geometric and iconic textures

Iconic textures were perceived as having a lower vibratory effect for all three chart types

Experiment 3

How does the use of textures affect chart reading?

Exp 3: Stimuli

- Top-rated geometric and iconic textures for bar and pie charts
- A unicolor fill as a baseline

carrot

mushroom

mushroom

olive

carrot

Exp 3: One Trail

Experiment 3 screenshot

Exp 3: How does the use of textures affect chart reading?

- 150 participants from Prolific
- Randomly assigned to either the bar chart or pie chart condition
- 60 trials per participant: 2 question types * 3 fill types * 10 datasets
- All orders were randomized to minimize order effects

Which has MORE?

Which has FEWER?

hart or pie chart condition pes * 3 fill types * 10 datasets

Exp 3: Results

Report sample means and pairwise mean differences with 95% Cls

For the following analysis, we included only the 86 participants with $\geq 90\%$ accuracy (45x Bar, 41x Pie)

Exp 3: Response time Differences are minimal

We only counted the correct trials

Conclusion

Effectiveness: Differences exist, but they are minor

- Texture is a viable option
- **Aesthetics:** The appeal of textures in visualization may be subjective
 - Recommend using textures for specific aesthetic preferences or particular requirements

Top-rated textures in our Experiment 2

Data embroidery with black-and-white textures alt.VIS Workshop 2023: <u>altvis.github.io</u>

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