## VISUAL ENCODING & DESIGN PROCESS

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# visual encodings guidelines process

## visual encodings



### how can you visually represent the numbers 4 and 8?



€	Magnitude Channels: Order	ed Attributes
	Position on common scale	
	Position on unaligned scale	⊢●┥ ┝───●┥
	Length (1D size)	
	Tilt/angle	/
	Area (2D size)	•
	Depth (3D position)	$\mapsto \bullet \longmapsto \bullet$
	Color luminance	
	Color saturation	
	Curvature	))))
	Volume (3D size)	· • •

### Identity Channels: Categorical Attributes





۲	Magnitude Channels: Ordered Attribut									
	Position on common scale									
	Position on unaligned scale	⊢●┥								
	Length (1D size)									
	Tilt/angle	/								
	Area (2D size)	•								
	Depth (3D position)	$\mapsto \bullet \longmapsto \bullet$								
	Color luminance									
	Color saturation									
	Curvature	))))								
	Volume (3D size)	· • •								





Least

where do these rankings come from?



### **Graphical Perception and Graphical** Methods for Analyzing Scientific Data

William S. Cleveland and Robert McGill

Graphs provide powerful tools both for analyzing scientific data and for communicating quantitative information. The computer graphics revolution, which began in the 1960's and has intensified during the past several years, stimulated the invention of graphical meth-

mation from graphs; theory and exp mental data are then used to order tasks on the basis of accuracy. The dering has an important application: d should be encoded so that the vis decoding involves tasks as high in ordering as possible, that is, tasks p

Summary. Graphical perception is the visual decoding of the quantitative a qualitative information encoded on graphs. Recent investigations have uncove basic principles of human graphical perception that have important implications the display of data. The computer graphics revolution has stimulated the inventior many graphical methods for analyzing and presenting scientific data, such as t plots, two-tiered error bars, scatterplot smoothing, dot charts, and graphing on a base 2 scale.

ods: types of graphs and types of quantitative information to be shown on graphs illustrated by several examples in wh (1-4). One purpose of this article is to some much-used graphical forms describe and illustrate several of these presented, set aside, and replaced new methods.

What has been missing, until recently, in this period of rapid graphical invention and deployment is the study of graphs and the human visual system. When a graph is constructed, quantitative and categorical information is encoded, chiefly through position, shape, size, symbols and color. When a person to visually extract quantitative inform

formed with greater accuracy. This new methods.

### **Elementary Tasks for the Graphical Perception of Quantitative Information**

The first step is to identify element graphical-perception tasks that are u

### ABSTRACT

Understanding perception is critical to effective visualization design. With its low cost and scalability, crowdsourcing presents an attractive option for evaluating the large design space of visualizations; however, it first requires validation. In this paper, we assess the viability of Amazon's Mechanical Turk as a platform for graphical perception experiments. We replicate previous studies of spatial encoding and luminance contrast and compare our results. We also conduct new experiments on rectangular area perception (as in treemaps or cartograms) and on chart size and gridline spacing. Our results demonstrate that crowdsourced perception experiments are viable and contribute new insights for visualization design. Lastly, we report cost and performance data from our experiments and distill recommendations for the design of crowdsourced studies.

**ACM Classification:** H5.2 [Information interfaces and presentation]: User Interfaces—Evaluation/Methodology

**General Terms:** Experimentation, Human Factors.

**Keywords:** Information visualization, graphical perception, user study, evaluation, Mechanical Turk, crowdsourcing.

### INTRODUCTION

### **Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design**

### **Jeffrey Heer and Michael Bostock**

**Computer Science Department** Stanford University {iheer, mbostock}@cs.stanford.edu

for ecological validity. Crowdsourced experiments may also substantially reduce both the cost and time to result.

Unfortunately, crowdsourcing introduces new concerns to be addressed before it is credible. Some concerns, such as ecological validity, subject motivation and expertise, apply to any study and have been previously investigated [13, 14, 23]; others, such as display configuration and viewing environment, are specific to visual perception. Crowdsourced perception experiments lack control over many experimental conditions, including display type and size, lighting, and subjects' viewing distance and angle. This loss of control inevitably limits the scope of experiments that reliably can be run. However, there likely remains a substantial subclass of perception experiments for which crowdsourcing can provide reliable empirical data to inform visualization design.

In this work, we investigate if crowdsourced experiments insensitive to environmental context are an adequate tool for graphical perception research. We assess the feasibility of using Amazon's Mechanical Turk to evaluate visualizations and then use these methods to gain new insights into visualization design. We make three primary contributions:

• We replicate prior laboratory studies on spatial data en-



## how much longer is B?





B



## how much larger is B?











B

## how much darker is B?



Α











**EXERCISE: encoding deconstruction** 





## a few guidelines... COLOR





















Points of View: Color Coding. B. Wong, Nature Methods, 2010.



## a few guidelines... COLOR get it right in black and white

## a few guidelines... COLOR get it right in black and white 3D





## a few guidelines... COLOR get it right in black and white 3D stay in the plane

## a few guidelines... COLOR get it right in black and white 3D stay in the plane ANIMATION





Same Stats, Different Graphs: Generating Datasets with Varied Appearance and Identical Statistics through Simulated Annealing. J. Matejka, G. Fitzmaurice, CHI, 2017.

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## a few guidelines... COLOR get it right in black and white 3D stay in the plane ANIMATION eyes over memory DECORATION





### Five Minutes With Eric Garcetti Mayor of Los Angeles



ic Garcetti envisions a Los Angeles where you don't need a car to live well. No car? In LA riously? But the city—and its new mayor—offers many surprises. Elected in May 2013 nd assuming the mayor's office in July, Garcetti is a fourth-generation Angeleno whose ackground-Mexican and lewish-befits an ethnically complex city where 220 languag are spoken. A Rhodes Scholar, the 42-year-old served on the city council for more than a decade, representing the distr des Hollywood, before becoming the city's oungest mayor in a century

ucture is

built: and a place that

How do vou want to make But what I would like to see is a Los Angeles where you don' Los Angeles better? need a car—where you can get to a neighborhood via various )ne, I want to reduce our city's modes of transport, but then you can walk around that neigh mplovment rate and make this borhood, shopping, eating, going to farmers markets. In the ca business-friendly city—a place capital of America, if we can show a reduction in pollution and a reduction in traffic by a combination of technology and other /here vou can't afford not to do disruptive forces like new car-share enterprises. I think people usiness; a place where the bestwill say: If LA can do it, we can do it, too. rained workforce exists; a place here the

Los Angeles Pop

Hawaiian & other Pacific Islander 6K 0.2%

/ Talk about vour transportatio

you feel is your platform. Two, I want to

make city government work again. I'm

a high-tech guy, and I want to build a

high-tech city hall that's focused on the

basics, like customer service and fixing

potholes, but which brings governmen

to you in an unexpected way—whether

it's smartphone apps or by sharing data

about your city with the public. In my first 100 days, I launched a new website

that has performance metrics so that

people can actually track what we're

doing well and what we're not doing we

initiatives. afford to live here. People would be very I think this is a kind of golden age of transportation in LA. The surprised at now many of our neighborhoods are walkable, are bikeable. The cliché that you're going to come out here and he voters passed measures in recent years to build out what is stuck in your car in traffic the whole time is not as true as it now the third-largest public transportation system in the country to improve the roads and highways and to reduce traffic used to be. —Gene Rebec

Conference Call, nma New Media Expo

**World Economic Forun** ual Meeting

28 JANUARY 2014 deltaskymag.com

### **Los Angeles Population By Race**

**e** The cliché that you're going to come out here and be stuck in your car in traffic the whole time is not as true as it used to be.



**iFX**EXPO iFX Expo Asia

What are some attributes that

Our economy is one of the most divers

and reflects the most creative people.

t's not iust Hollywood and TV. We've

ot three top-25 universities here—no

other city has that. We have a collection

of incredible neighborhood "villages,

where people are inventing food in a

new way, mashing up cultures so tha<sup>.</sup>

Korean short rib tacos are the latest

craze. I think also that a lot of people

don't realize how much Los Angeles

There are more artists that live and

create here—almost what happened to

New York in the '70s and '80s is going

on in LA now, because artists still can

has become the art capital of the work

eople might find surprising

about your hometown?



*Source:* United States Census Bureau, 2012 estimates. *Note:* The concept of race is separate from the concept of origin; 48 percent of respondents identified themselves as "Hispanic or Latino" but fall into one of the above groups.

## a few guidelines... COLOR get it right in black and white 3D stay in the plane ANIMATION eyes over memory **DECORATION** show data variation, not design variation



### visual encodings are ranked

### - guidelines:

- get it right in black and white
- stay in the plane
- eyes over memory
- show data variation, not design variation

## process



### MANFRED GRABHERR













































### "Honestly . . . I don't think I would ever have gotten here."



visualization design is a process





understand ideate make deploy



Design Activity Framework for Visualization Design. S. McKenna, D. Mazur, J. Agutter, M. Meyer, IEEE TVCG (InfoVis), 2014.





### evaluate

Design Activity Framework for Visualization Design. S. McKenna, D. Mazur, J. Agutter, M. Meyer, IEEE TVCG (InfoVis), 2014.



ideate make deploy

## understand

### evaluate

Design Activity Framework for Visualization Design. S. McKenna, D. Mazur, J. Agutter, M. Meyer, IEEE TVCG (InfoVis), 2014.





# data counseling interviews, exploratory data analysis, rapid prototyping



### -data counseling benefits from a diverse set of stakeholders -talk to many -be thoughtful and purposeful in an interview -interview in the wild

### -fail fast... prototype rapidly -your best ideas are usually not your first ones -prototypes are a way to learn about problem



## a partial and imperfect representation of the thing the analyst cares about

	Α	B C	D	E	F	G	н	1	J	K	L	М	N	0	P	Q
1	Title	Year Genre_1	Genre_2	Genre_3	Director	Writer_1	Writer_2	Writer_3	Actors_1	Actors_2	Actors_3	Actors_4	Metascore	imdbVotes	Language	Country
2	Deadpool	2016 Action	Adventure	Comedy	Tim Miller	Rhett Reese	Paul Wernick	Fabian Niciez	Ryan Reynold	Karan Soni	Ed Skrein	Michael Beny	65	326	English	USA
3	The Jungle B	2016 Adventure	Drama	Family	Jon Favreau	Justin Marks	Rudyard Kipl	?	Neel Sethi	Bill Murray	Ben Kingsley	Idris Elba	78	15	English	USA
4	The Shawsha	1994 Crime	Drama	?	Frank Darabo	Stephen King	Frank Darabo	?	Tim Robbins	Morgan Free	Bob Gunton	William Sadle	80	1	English	USA
5	The Godfath	1972 Crime	Drama	?	Francis Ford	Mario Puzo	Francis Ford	Mario Puzo	Marlon Bran	Al Pacino	James Caan	Richard S. Ca	100	1	English	USA
6	The Godfath	1974 Crime	Drama	?	Francis Ford	Francis Ford	Mario Puzo	Mario Puzo	Al Pacino	Robert Duva	Diane Keator	Robert De Ni	80	771	English	USA
7	The Dark Kni	2008 Action	Crime	Drama	Christopher	Jonathan No	Christopher I	Christopher I	Christian Bal	Heath Ledge	Aaron Eckhai	Michael Cain	82	1	English	USA
8	Schindlers Li:	1993 Biography	Drama	History	Steven Spiel	Thomas Kene	Steven Zaillia	?	Liam Neeson	Ben Kingsley	Ralph Fienne	Caroline Goo	93	844	English	USA
9	12 Angry Me	1957 Crime	Drama	?	Sidney Lume	Reginald Ros	<b>Reginald Ros</b>	?	Martin Balsa	John Fiedler	Lee J. Cobb	E.G. Marshal	?	431	English	USA
10	Pulp Fiction	1994 Crime	Drama	?	Quentin Tara	Quentin Tara	Roger Avary	Quentin Tara	Tim Roth	Amanda Plur	Laura Lovela	John Travolta	94	1	English	USA
11	The Lord of t	2003 Adventure	Drama	Fantasy	Peter Jackson	J.R.R. Tolkier	Fran Walsh	Philippa Boye	Noel Appleby	Ali Astin	Sean Astin	David Aston	94	1	Quenya	USA
12	Fight Club	1999 Drama	?	?	David Finche	Chuck Palahr	Jim Uhls	?	Edward Nort	Brad Pitt	Meat Loaf	Zach Grenier	66	1	English	USA
13	The Lord of t	2001 Adventure	Drama	Fantasy	Peter Jackson	J.R.R. Tolkier	Fran Walsh	Philippa Boy	Alan Howard	Noel Appleb	Sean Astin	Sala Baker	92	1	English	New Zealan
14	Star Wars: E	1980 Action	Adventure	Fantasy	Irvin Kershne	Leigh Bracke	Lawrence Ka	George Luca:	Mark Hamill	Harrison For	Carrie Fisher	Billy Dee Wil	79	810	English	USA
15	Forrest Gum	1994 Drama	Romance	?	Robert Zeme	Winston Gro	Eric Roth	?	Tom Hanks	Rebecca Will	Sally Field	Michael Con	82	1	English	USA
16	Inception	2010 Action	Mystery	Sci-Fi	Christopher	Christopher I	?	?	Leonardo Di	Joseph Gord	Ellen Page	Tom Hardy	74	1	English	USA
17	The Lord of t	2002 Action	Adventure	Drama	Peter Jackson	J.R.R. Tolkier	Fran Walsh	Philippa Boy	Bruce Allpres	Sean Astin	John Bach	Sala Baker	88	1	English	USA
18	One Flew Ov	1975 Drama	?	7	Milos Forma	Lawrence Ha	Bo Goldman	Ken Kesey	Michael Berr	Peter Brocco	Dean R. Broc	Alonzo Brow	79	665	English	USA
19	Goodfellas	1990 Biography	Crime	Drama	Martin Scors	Nicholas Pile	Nicholas Pile	Martin Scors	Robert De Ni	i Ray Liotta	Joe Pesci	Lorraine Brac	89	711	English	USA
20	The Matrix	1999 Action	Sci-Fi	?	Lana Wachow	Lilly Wachow	Lana Wachow	?	Keanu Reeve	Laurence Fis	Carrie-Anne	Hugo Weavir	73	1	English	USA
21	Star Wars: E	1977 Action	Adventure	Fantasy	George Luca	George Luca:	?	?	Mark Hamill	Harrison For	Carrie Fisher	Peter Cushin	92	886	English	USA
22	Se7en	1995 Crime	Drama	Mystery	David Finche	Andrew Kevi	?	?	Morgan Free	Andrew Kevi	Daniel Zacap	Brad Pitt	65	991	English	USA
23	The Silence c	1991 Crime	Drama	Thriller	Jonathan De	Thomas Harr	Ted Tally	?	Jodie Foster	Lawrence A.	Kasi Lemmor	Lawrence T.	84	857	English	USA
24	lts a Wonder	1946 Drama	Family	Fantasy	Frank Capra	Frances Goo	Albert Hacke	Frank Capra	James Stewa	Donna Reed	Lionel Barryn	Thomas Mite	?	268	English	USA
25	The Usual Su	1995 Crime	Drama	Mystery	Bryan Singer	Christopher I	?	?	Stephen Balo	Gabriel Byrn	Benicio Del T	Kevin Pollak	77	718	English	USA
26	Léon: The	1994 Crime	Drama	Thriller	Luc Besson	Luc Besson	?	?	Jean Reno	Gary Oldmar	Natalie Portr	Danny Aiello	64	707	English	France
27	Saving Privat	1998 Action	Drama	War	Steven Spiel	Robert Roda	?	?	Tom Hanks	Tom Sizemor	Edward Burn	Barry Pepper	90	857	Czech	USA
28	American His	1998 Crime	Drama	?	Tony Kaye	David McKer	?	?	Edward Nort	Edward Furle	Beverly DAng	Jennifer Lien	62	766	English	USA
29	Interstellar	2014 Adventure	Drama	Sci-Fi	Christopher	Jonathan No	Christopher I	?	Ellen Burstyn	Matthew Mo	Mackenzie Fo	John Lithgow	74	884	English	USA
30	Casablanca	1942 Drama	Romance	War	Michael Curt	Julius J. Epste	Philip G. Epst	Howard Kocł	Humphrey B	Ingrid Bergm	Paul Henreid	<b>Claude Rains</b>	?	377	English	USA
31	City Lights	1931 Comedy	Drama	Romance	Charles Chap	Charles Chap	?	?	Virginia Cher	Florence Lee	Harry Myers	Al Ernest Gar	?	104	English	USA
32	Psycho	1960 Horror	Mystery	Thriller	Alfred Hitcho	Joseph Stefa	Robert Bloch	?	Anthony Per	Vera Miles	John Gavin	Janet Leigh	?	408	English	USA
33	Raiders of th	1981 Action	Adventure	?	Steven Spiel	Lawrence Ka	George Luca:	Philip Kaufm	Harrison For	Karen Allen	Paul Freema	Ronald Lacey	90	639	English	USA
34	Rear Windov	1954 Mystery	Thriller	?	Alfred Hitcho	John Michae	Cornell Wool	?	James Stewa	Grace Kelly	Wendell Core	Thelma Ritte	?	309	English	USA
35	Modern Time	1936 Comedy	Drama	?	Charles Chap	Charles Chap	?	?	Charles Chap	Paulette Goo	Henry Bergm	Tiny Sandfor	96	138	English	USA
36	The Green M	1999 Crime	Drama	Fantasy	Frank Darabo	Stephen King	Frank Darabo	?	Tom Hanks	David Morse	Michael Clarl	Bonnie Hunt	61	758	French	USA
37	Terminator 2	1991 Action	Sci-Fi	?	James Came	James Camei	William Wish	?	Arnold Schw	Linda Hamilt	Edward Furlo	Robert Patric	75	728	English	USA
38	The Pianist	2002 Biography	Drama	War	Roman Polar	Ronald Harw	Wladyslaw S	?	Adrien Brody	Emilia Fox	Michal Zebro	Ed Stoppard	85	482	English	France
39	The Departer	2006 Crime	Drama	Thriller	Martin Scors	William Mon	Alan Mak	Felix Chong	Leonardo Di	Matt Damon	Jack Nicholso	Mark Wahlb	86	845	English	USA
40	Back to the F	1985 Adventure	Comedy	Sci-Fi	Robert Zeme	Robert Zeme	Bob Gale	?	Michael J. Fo	Christopher	Lea Thompso	Crispin Glove	86	707	English	USA
41	Whiplash	2014 Drama	Music	?	Damien Chaz	Damien Chaz	?	?	Miles Teller	J.K. Simmons	Paul Reiser	Melissa Bend	88	377	English	USA



### select proxies



action: thing you want to do object: items you want to take action on measure: value you are interested in for the objects



### select proxies



action: thing you want to do object: items you want to take action on measure: value you are interested in for the objects



### Identify good directors. director :: movie

### select proxies



action: thing you want to do object: items you want to take action on measure: value you are interested in for the objects



### Identify good directors. director :: movie good :: high IMDB rating Identify movies with high IMDB ratings.

### select proxies



action: thing you want to do object: items you want to take action on **measure:** value you are interested in for the objects



## high rating vs popularity





- providing context
- iterative and benefits from data counseling

- identifying proxies is a core part of (data) science visualization helps in refining and validating by

defining the problem you are trying to solve is

## **EXERCISE:** proxies



# How do Facebook users' online behavior change when their parents join Facebook?

Hint: consider behavior, change, and parents

## - creating visualizations is a design process - find proxies in the data for what you care about - use data counseling to identify, refine, and

- validate proxies

## recommended reading

Intentional Communication from Data to Display



O'REILLY\*

Noah Iliinsky & Julie Steele

![](_page_69_Picture_5.jpeg)

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![](_page_69_Picture_7.jpeg)