Introduction to Human-Computer Interaction

Information Visualization

Lecture 7

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with acknowledgements to: Petra Isenberg

After today you will...

- have gained an overview of the research area
- learned basic principles of data representation and interaction

INFORMATION VISUALIZATION

Why



If the Digital Universe were represented by the memory in a stack of tablets, in **2013** it would have stretched two-thirds the way to the Moon*

By **2020**, there would be 6.6 stacks from the Earth to the Moon*

It is estimated that 4.4 ZB (4.4 x 10²¹) of digital information was generated in 2013





It's not easy to get a handle on jobs in data science. However, data from O'Reilly Research shows a steady year-over-year increase in Hadoop and Cassandra job listings, which are good proxies for the "data science" market as a whole. This graph shows the increase in Cassandra jobs, and the companies listing Cassandra positions, over time.

"The ability to take data -- to be able to understand it, to process it, to extract value from it, to visualize it, to communicate it that's going to be a hugely important skill in the next decades."

Hal Varian, chief economist at Google

Question

how can we effectively access data?

- understand its structure?
- make comparisons?
- make decisions?
- gain new knowledge?
- convince others?

-...

Many possible ways to address...



Example

1		П		ш		IV		
x	У	х	У	x y		х	У	
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58	
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76	
13.0	7.58	13.0	8.74	13.0 12.74		8.0	7.71	
9.0	8.81	9.0 8.77 9.0		9.0	7.11	8.0	8.84	
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47	
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04	
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25	
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50	
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56	
7.0	4.82	7.0	7.26	7.0 6.42		8.0	7.91	
5.0	5.68	5.0 4.74		5.0	5.73	8.0	6.89	

Raw Data from Anscombe's Quartet

Statistical Analysis

For all four columns, the statistics are identical

I		I	I	I	II	IV		
x	У	x	У	x	У	x	У	
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58	
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76	
13.0	7.58	13.0	8.74	13.0 12.74		8.0	7.71	
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84	
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47	
14.0	9.96	14.0	8.10	14.0	14.0 8.84		7.04	
6.0	7.24	6.0 6.13		6.0	6.08	8.0	5.25	
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50	
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56	
7.0	4.82	7.0 7.26		7.0 6.42		8.0	7.91	
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89	

Mean of x	9.0
Variance of <i>x</i>	11.0
Mean of y	7.5
Variance of y	4.12
Correlation between <i>x</i> and <i>y</i>	0.816
Linear regression line	y = 3 + 0.5x

Visual Representation of the Data

Visual representation reveals a different story

	l	I	I	I	II	IV		
x	У	x	У	x	У	x	У	
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58	
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76	
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71	
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84	
11.0	8.33	11.0	9.26	9.26 11.0 7		8.0	8.47	
14.0	9.96	14.0	8.10	14.0 8.84		8.0	7.04	
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25	
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50	
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56	
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91	
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89	



хЗ

x4

Why visual data representations?

- Vision is our most dominant sense
- We are very good at recognizing visual patterns
- We need to see and understand in order to explain, reason, and make decisions



all examples from: http://vis.stanford.edu/protovis/

Other benefits of visualization

- expand human working memory
 - offload cognitive resources to the visual system,
- reduce search
 - by representing a large amount of data in a small space,
- enhance the recognition of patterns
 - by making them visually explicit
- aid monitoring of a large number of potential events
- provides a manipulable medium & allows exploration of a space of parameter values.

百間不如一見

"One hundred rumors are not comparable to one look."

An Old Chinese Inscription

Via Brinton, Graphic Presentation, 1939

Information visualization

- Create visual representation
- Concentrates on abstract data
- Includes interaction

Official Definition:

The use of computer-supported, interactive, visual representations of abstract data to amplify cognition. [Card et al., 1999]



Functions of Visualizations

- Recording information
 - Tables, blueprints, satellite images
- Processing information
 - needs feedback and interaction
- Presenting information
 - share, collaborate, revise
 - for oneself, for one's peers and to teach
- Seeing the unseen

Visualization of abstract data has been practiced for hundreds of years...

HISTORICAL EXAMPLES

The Broadway Street Pump

- In 1854 cholera broke out in London
 - 127 people near Broad Street died within 3 days
 - 616 people died within 30 days
- "Miasma in the atmosphere"
- Dr. John Snow was the first to link contaminated water to the outbreak of cholera
- How did he do it?
 - he talked to local residents
 - identified a water pump as a likely source
 - used maps to illustrate his theory
 - convinced authorities to disable the pump





John Snow, 1854

Napoleon's March on Moscow Charles Minard, 1869

Named the best statistical graphic ever drawn (by Edward Tufte)

- Includes: spatial layout linked with stats on: army size, temperature, time
- Tells a story in one overview



More info: The Visual Display of Quantitative Information (Tufte)



... AND VERY RECENTLY

TrashTrack



Winner of the NSF International Science & Engineering Visualization Challenge! http://senseable.mit.edu/trashtrack/

Artificial Intelligence



http://www.turbulence.org/spotlight/thinking/chess.html

Open Data

- Movement making government data freely available
- Encourage participation by everyone



Many Eyes

Visualizations : US government expenses 1962-2004

• Upload data, create visualizations, discuss

• Distributed asynchronous collaboration

```
Uploaded by: Frank van Ham
                                              Created at: Jan 10 2007
Description: Where have your tax dollars gone?
Tags: us budget gov
Stack Hierarchy (Drag to Reorder) Category Subcategory Sub-subcategory
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Data file: US Budget, $Millions, 1962-2004 (Y2000$)
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The share watch this add to topic center
Comments (46)
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Specific Visualization Environments



Molecular visualisation in the Reality Cube University of Groningen, NL



Tabletops for Visualization University of Calgary



WILD Wall, INRIA

Software Visualization



(Voineaet al., SoftVis, 2005)

Text Visualization

Parallel Tag Clouds to Explore Faceted Text Corpora (Collins et al., VAST 2009)

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Graphs



Family Trees



http://www.aviz.fr/geneaquilts/

Geographic Visualization

http://data-arts.appspot.com/globe

Weather



http://weatherspark.com/

Data Dashboards



GLOBALL SPIROMETRY

http://globalspirometry.com

Resources for more examples

- Visualization conferences
- Blogs
 - <u>http://infosthetics.com/</u>
 - <u>http://fellinlovewithdata.com/</u>
 - <u>http://eagereyes.org/</u>
 - <u>http://flowingdata.com/</u>
 - <u>http://www.informationisbeautiful.net/</u>
- Books
 - Textbooks
 - Readings in Information Visualization: Using Vision to Think (a bit old now but good intro)
 - Information Visualization (Robert Spence a light intro, I recommend as a start)
 - Information Visualization Perception for Design (Colin Ware, focused on perception and cognition)
 - Interactive Data Visualization: Foundations, Techniques, and Applications (Ward et al. most recent)
 - Examples
 - Beautiful Data (McCandless)
 - Now You See it (Few)
 - Tufte Books: Visual Display of Quantitative Information (and others)
 - ... (many more, ask me for details)

It is difficult to create

CREATE VISUALIZATIONS


What is a representation?

- A representation is
 - a formal system or mapping by which the information can be specified (D. Marr)
 - a sign system in that it stands for something other than its self.
- for example: the number thirty-four



Presentation

• different representations reveal different aspects of the information

decimal: counting & information about powers of 10, binary: counting & information about powers of 2, roman: impress your friends (outperformed by positional system)

presentation

how the representation is placed or organized on the screen

<u>34,</u> **34,** <u>34</u>

Principles of Graphical Excellence

- Well-designed presentation of interesting data a matter of *substance*, *statistics*, *design*
- Complex ideas communicated with clarity, precision, efficiency
- Gives the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space
- Involves almost always multiple variables
- Tell the truth about the data

Or a bit more simply...

- Solving a problem simply means representing it so as to make the solution transparent ... (Simon, 1981)
- Good representations:
 - allow people to find relevant information
 - information may be present but hard to find
 - allow people to compute desired conclusions
 - computations may be difficult or "for free" depending on representations

Good representation?

🖷 Table - StateData ()							
			Load	Snap	Minnesota	30.4%	14389
State	1	College Degree %	Per Capita Inco	ome	Mississippi	19.9%	9648
Alak	nama	20.6%	114	186	Missouri	22.3%	12989
	vka	30.3%	176	100	Montana	25.4%	11213
		27.1%	170	101	Nebraska	26.0%	12452
Anzu	<u>una</u>	17.0%	104		Nevada	21.5%	15214
	ansas	17.0%	105	20	New Hampshire	32.4%	15959
Calif	tornia	31.3%	164	109	New Jersey	30.1%	18714
Cold	orado	33.9%	148	21	New Mexico	25.5%	11246
Con	necticut	33.8%	201	89) L	New York	29.6%	16501
Dela	aware	27.9%	158	54	North Carolina	24.2%	12885
Dist	rict of Columbia	36.4%	188	81	North Dakota	28.1%	11051
Elori	ida	22 9%	146		Ohio	22.3%	13461
	iua.	24.370	170	21	Oklahoma	22.8%	11893
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Mas	sachusetts	34.5%	172	24	Wisconsin	24.9%	13276
Micł	nigan	24.1%	141	54		25.7%	42311
Minr	resota	30.4%	143	89	•		•

Good representation!



How do we arrive at a visualization?



Interaction

The Visualization Pipeline

From [Spence, 2000]

Visualization Reference Model

Also a visualization pipeline a bit expanded



From [Card et al., Readings in Information Visualization]

Pitfalls

- Selecting the wrong data
- Selecting the wrong data structure
- Filtering out important data
- Failed understanding of the types of things that need to be shown
- Choosing the wrong representation
- Choosing the wrong presentation format
- Inappropriate interactions provided to explore the data

Recap

- So far you
 - learned what information visualization is
 - learned about the advantages of visualization
 - saw a number of examples (historical and new)
 - tried to create your own first visualization from a dataset
- Next
 - you will get to know your data
 - you will learn about the basic components of visualization
 - try another example

Data

- Data is the foundation of any visualization
- The visualization designer needs to understand
 - the data properties
 - know what meta-data is available
 - know what people want from the data

Nominal, Ordinal and Quantitative

- Nominal (labels)
 - Fruits: apples, oranges
- Ordered
 - Quality of meat: grade A, AA, AAA
 - Can be counted and ordered, but not measured
- Quantitative: Interval
 - no clear zero (or arbitrary)
 - e.g. dates, longitude, latitude
 - usually compare differences (intervals)
- Quantitative: Ratio
 - meaningful origin (zero)
 - physical measurements (temperature, mass, length)
 - counts and amounts

Nominal, Ordinal and Quantitative

- Nominal (labels)
 - Operations: =, ≠
- Ordered
 - Operations: =, \neq , <, >
- Quantitative: Interval
 - Operations: =, ≠, <, >, -, +
 - Can measure distances or spans
- Quantitative: Ratio
 - Operationrs: =, ≠, <, >, , +, ×, ÷
 - Can measure ratios or proportions



[1989–1999] + [2002–2012]

10kg / 5kg

S.S. Stevens, On the theory of scales of measurements, 1946

Data-Type Taxonomy

- 1D (linear)
- Temporal
- 2D (maps)
- 3D
- nD (relational) vis examples later
- Trees (hierarchies)
- Networks (graphs)



Shneiderman: The Eyes Have It

Why is this important?

- Nominal, ordinal, and quantitative data are best expressed in different ways visually
- Data types often have inherent tasks
 - temporal data (comparison of events)
 - trees (understand parent-child relationships)
 - ..
- But:
 - any data type (1D, 2D,...) can be expressed in a multitude of ways!

Visualization's Main Building Blocks

Marks which represent:



From Semiology of Graphics (Bertin)

Visual Variables Applicable to Marks



From Semiology of Graphics (Bertin)

Additional Variables for Computers

- motion
 - direction, acceleration, speed, frequency, onset, 'personality'

- saturation
 - colour as Bertin uses largely refers to hue, saturation != value





Additional Variables for Computers

- flicker
 - frequency, rhythm, appearance
- depth? 'quasi' 3D
 - depth, occlusion, aerial perspective, binocular disparity
- Illumination

transparency



Characteristics of Visual Variables

- Selective: Is a change in this variable enough to allow us to select it from a group?
- Associative: Is a change in this variable enough to allow us to perceive them as a group?
- Quantitative:

Is there a numerical reading obtainable from changes in this variable?

• Order:

Are changes in this variable perceived as ordered?

 Length (resolution): Across how many changes in this variable are distinctions possible?

Visual Variables

Visual Variable	Selective	Associative	Quantitative Order		Length	
Position	Yes	Yes	Yes	Yes Yes Dependant on reso		
Size	Yes	Yes	Approximate	Yes	Association: 5; Distinction: 20	
Shape	With Effort	With Effort	No	No	Infinite	
Value	Yes	Yes	No	Yes	Association: 7; Distinction: 10	
Hue	Yes	Yes	No	No	Association: 7; Distinction: 10	
Orientation	Yes	Yes	No	No	4	
Grain	Yes	Yes	No	No	5	
Texture	Yes	Yes	No	No	Infinite	
Motion	Yes	Yes	No	Yes	Unknown	

Elementary Graphical Perception Tasks

William S. Cleveland 1980s

- Performed controlled experiments to find out how effectively people could judge changes in visual features
- Focus on quantitative information
- Variables used: angle, area (size), color hue, color saturation, density (value), length, position, slope, volume

Value

 What percentage in value is the right from the left (=100%)?







Value

 What percentage in value is the right from the left (=100%)?







Area

 What percentage in size is the right from the left (=100%)?







Area

 What percentage in size is the right from the left (=100%)?





36%

Area

 What percentage in size is the red from the blue (=100%)?





no idea – this is very difficult

Length

 What percentage in length is the right from the left (=100%)?





Length / Position

 What percentage in length is the right from the left (=100%)?





Effectiveness of Data Encodings (Conjecture)

Quantitative	 Ordinal		Nominal
Position	 Position		Position
Length	Density		Color Hue
Angle	Color Saturation		Texture
Slope	Color Hue	$\langle \rangle \rangle$	Connection
Area	Texture		Containment
Volume	Connection		Density
Density	Containment		Color Saturation
Color Saturation	Length		Shape
Color Hue	Angle		Length
Texture	Slope		Angle
Connection	Area		Slope
Containment	Volume		Area
Shape	 Shape		Volume

Mackinlay 1986

ASSESS VISUAL REPRESENTATIONS

Applying what we know to

Car / Nation	USA	Japan	Germany	France	Sweden
Accord		Х			
AMC Pacer	X				
Audi 5000			Х		
BMW 320i			Х		
Champ	Х				
Chev Nova	X				
Saab 9000				Х	

What kind of data are we looking at?

Nations: Nominal Cars: Nominal (Nation,Car): Nominal



Problem:

Length of bar suggests an order or quantity (e.g. Swedish cars are better)



Better!

Banks: Market Cap

- Market Value as of January 20th 2009, \$Bn
- Market Value as of Q2 2007, \$Bn


Problems here?

Banks: Market Cap

Market Value as of Januar 🖕 We are not good at comparing areas 0 Market Value as of Q2 200 BNP RBS UBS Paribas Societe Barclays Unicredit 120 Deutsche 116 Credit Generale 108 Bank Morgan Agricole 93 91 Stanley 80 76 67 4.6 10.3 7.4 32.5 35 17 26 Citigroup HSBC 255 215 JP Morgan 165 Santander **Goldman Sachs** 116 **Credit Suisse** 100 19 85 97

J.P.Morgan

While JPMorgan considers this information to be reliable, we cannot guarantee its accuracy or completeness

Problems here?

Banks: Market Cap





[Cartography: Thematic Map Design, Figure 8.6, p. 170, Dent, 96] **S = 0.98A^{0.67}** [from Flannery 71]

Magnitude estimation experiments

?

100%

• We did a very(!) simplified magnitude estimation experiment earlier (comparing stimulus/modulus)

 Stevens' power law describes a relationship between a physical stimulus (S) and its perceived intensity or strength (P)

$$P = kS^n$$



Perception

- People tend to correctly estimate lengths
- They tend to **underestimate areas and volumes.**
 - When asked to pick a circle that is two times the size of another most people would pick a circle ~1.8 times the size. This tendency gets worse with larger areas, and is worse in general for estimations of volumes.



http://makingmaps.net/2007/08/28/perceptual-scaling-of-map-symbols/

Problem here?

	Contraction and		
FINANCIALS	21.45%	NON-CYCLICAL CONSUMER GOODS	18.09%
CYCLICAL SERVICES	14.17%	INFORMATION TECHNOLOGY	13.61%
RESOURCES	9.61%	GENERAL INDUSTRIES	8.99%
UTILITIES	3.83%	BASIC INDUSTRIES	3.70%
NON-CYCLICAL SERVICES	3.67%	CYCLICAL CONSUMER	1.87%

- Pie slices are difficult to compare in area
- There is likely a bug or error in the data
- Perspective distortion adds to the problem
- Colors are difficult to distinguish

Similarly...3D bar charts are not recommended



This is much easier to see and compare!

Problem here?

NEWS MAGAZINE STAFF SIZE OVER TIME

Time and Newsweek select years 1983 - 2005



NUMBER OF CORRESPONDENTS IN BUREAUS OVER TIME



Time and Newsweek, select years 1983 - 2005

NEWS MAGAZINE BUREAUS OVER TIME



Length Comparison



At first glance: 2003: Newsweek is 50% of Times If we add a proper o: 2003: Newsweek is ~80% of Times

Moreover...

NEWS MAGAZINE STAFF SIZE OVER TIME

Time and Newsweek select years 1983 - 2005



Redesign (by Stephen Few)



Note: A dashed line connecting two points indicates that there are years between the points for which values were not available. If the values were available, the shape of the lines might vary significantly.

NEWS MAGAZINE STAFF SIZE OVER TIME





2003

2004

2005

NUMBER OF CORRESPONDENTS IN BUREAUS OVER TIME

1993

Time and Newsweek, select years 1983 - 2005

1983

160



NEWS MAGAZINE BUREAUS OVER TIME

Time and Newsweek select years 1983 - 2005



Perception and Charts

- Bar Charts
- Line Charts
- Pie Charts
- Dot Charts





A few more words on charts



Good reference: How to Lie with Statistics, by Darrell Huff

• Provide a proper baseline



A 10% increase. Good!



• Provide a proper baseline & label your axes



- Provide a proper baseline & label your axes
- Avoid eye-candy



True data



same data with eye-candy & no numbers but tells the same general story



impressive but a lie!

- Provide a proper baseline & label your axes
- Avoid eye-candy
- Don't make people compare areas when not necessary





Adapted by courtesy of STEELWAYS.

Schwimmende Schlote

Der internationale Schiffsverkehr boomt. Seit 1990 hat sich der Treibstoffverbrauch auf dem Meer verdoppelt. Die dreckigen Abgase der Schiffe gelangen weitgehend ungefiltert in die Atmosphäre

http://images.zeit.de/wissen/2011-04/s41-infografik-schiffsverkehr.pdf

3372

1436

GETREIDE

ANDER

9516

4120

ERZE

ANDE

ERE ANDERE

NOERE ANDERE

ANDERE ANDERE

Do the boxes represent the little white numbers??

> Transporte per Schiff im Jahr 2006 nach Gütern (in Milliarden Tonnenmeilen)

- Provide a proper baseline & label your axes
- Avoid eye-candy
- Don't make people compare areas when not necessary
- Provide legends

- Provide a proper baseline & label your axes
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- Provide legends
- Grids help but make them subtle (no black lines!)



- Provide a proper baseline & label your axes
- Avoid eye-candy
- Don't make people compare areas when not necessary
- Provide legends
- Grids help but make them subtle (no black lines!)
- Many more...

The Visual Display of Quantitative Information EDWARD R. TUFTE





Graph



A book that can vastly increase what you learn from your data

Summary

- Now you know the main building blocks are marks
- Marks are modified by **visual variables**
- Visual variables have **specific characteristics**
- These characteristics influence how the data will be perceived

15 minute break then

LAB

What will the exam be about?

- lectures 1-6
- mainly (not a comprehensive list):
 - user interfaces
 - user interface design cycle
 - evaluation for requirements and during design
- 3 parts
 - course questions
 - UI critique
 - creative task
- memorization alone will not help you. You need to be able to apply your knowledge

top 10: how best to fail the exam?

- 10 I don't bother reading the instructions at the top. Questions are what counts!
- 9 I never read questions through completely, and also read them only once.
- 8 I start answering the questions without reading the whole exam first, so later questions remain a surprise and the last 10 minutes are exciting!
- 7 Once I am through, I hand in my answers immediately; by going though everything again I would only risk finding mistakes in my replies.
- 6 I never check that I really answered all questions, that's for losers.
- 5 If a question asks me for some fact **and** to briefly **explain** it, I only give fact/result, but not the explanation that would be silly.
- 4 I ignore **bold** or *italic* parts, this is just fancy typesetting with no meaning.
- 3 I do not write keywords but essays this nicely fills the limited exam time.
- 2 If the question asks for 3 things, I give **one** and name it slightly differently 3x. Surely the instructor won't notice!
- 1 I completely ignore the number of points given per question. I write 1 sentence for a 10-point question, but a whole page for a 1-point question.

Now lab time...

recap: Jakob Nielsen's Heuristics

- 1. Visibility of system status
- 2. Match between system and real world
- 3. User control and freedom
- 4. Consistency and standards
- 5. Error prevention
- 6. Recognition over recall
- 7. Flexibility and efficiency of use
- 8. Aesthetic and minimalist design
- 9. Help users recognize, diagnose, and recover from errors
- 10. Help and documentation

heuristic evaluation

- idea: apply heuristics to eval of a user interface
- we will use your vertical prototype

heuristic evaluation – step by step

- 1. plan your evaluation by either
 - 1. developing a set of tasks for your evaluators
 - 2. providing evaluators with the goal of the tool and let them come up with their own tasks (works well if they know the users well)
 - 3. ask evaluators to go through each screen / dialog and assess it
- 2. choose your evaluators (preferably with experience)
- 3. review heuristics
- 4. conduct the analysis
- 5. analyze the results

5 minutes: develop a task description

- meet with your project team
- write down a task description for your evaluators

15 minutes 2x

- go into specific groups (pre-assigned)
- guide:
 - one person from development team
 - gives the task, says what the system can do and gives short usage instructions
 - take a HE worksheet
- evaluators:
 - together evaluate the UI by stepping through the task and the UI components (dialogs, widgets, screens, etc.) and answering the
 - use the HE worksheet to record the problems found

15 minutes: heuristic eval I

- Accurate Learning
 - Guide:
 - Evaluators:
- Cook and Shop
 - Guide:
 - Evaluators:
- EasyCracy
 - Guide:
 - Evaluators:
- FocusMore!
 - Guide:
 - Evaluators:
- CroceryShopping
 - Guide:
 - Evaluators:

- Project Aggregator
 - Guide:
 - Evaluators:
- SmartNews
 - Guide:
 - Evaluators:
- Social Penguin
 - Guide:
 - Evaluators:
- Travel for Dummies
 - Guide:
 - Evaluators:
- WhaleManager
 - Guide:
 - Evaluators:

15 minutes: heuristic eval II

- Accurate Learning
 - Guide:
 - Evaluators:
- Cook and Shop
 - Guide:
 - Evaluators:
- EasyCracy
 - Guide:
 - Evaluators:
- FocusMore!
 - Guide:
 - Evaluators:
- CroceryShopping
 - Guide:
 - Evaluators:

- Project Aggregator
 - Guide:
 - Evaluators:
- SmartNews
 - Guide:
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- Social Penguin
 - Guide:
 - Evaluators:
- Travel for Dummies
 - Guide:
 - Evaluators:
- WhaleManager
 - Guide:
 - Evaluators:

10 minutes: analysis + presentation of the results

- go back to your project team
- review the two worksheets filled in by the evaluators
- write a list of high priority fixes for your tool
- present your list to class