Annotated Sources

Link to this doc:
https://docs.google.com/document/d/10RqXxM6M5qQrAffpQR-7r3dV3grdlDgt2br59F4xV1A/edit?usp=sharing

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Author: Bum Chul Kwon and Bongshin Lee

Title: A Comparative Evaluation on Online Learning Approaches using Parallel Coordinate Visualization.

Venue(Conference, Booktitle): Proceedings of the SIGCHI Conference on Human Factors in Computing Systems

Year: 2016

Aim: "Visualizations are increasingly used as storytelling medium for the general public, it becomes important to help people learn how to understand visualization." The overall gist was to investigate the efficiency of four different online learning techniques, baseline (no tutorial), static tutorial, video tutorial, and interactive tutorial. So depending on what type of online learning technique, people can learn better.

Conclusion: Four experimental conditions were conceived and it turns out that interactive tutorials led to higher scores than static/baseline conditions with statistical importance whereas interactive tutorials did better than video tutorials but held no statistical importance.

How does what they're saying inform how we design interventions / feedback for people? Based on the findings of the experiment, it seems an interactive type of tutorial helps people learn data visualizations better. So if we can **design some sort of intervention that is interactive, or feedback that's interactive, it could help people learn visualizations quicker.**

Author: Annika Wolff, Daniel Gooch, and Gerd Kortuem.

Title: Data Literacy to Support Human-centred Machine Learning.

Venue(Conference, Booktitle): Human Centred Machine Learning at CHI 2016

Year: 2016

Aim: Results of machine learning would either “be read by experts or else interpreted for the public, with the methods hidden from view”. The goal of the paper is to investigate whether “improving the overall data literacy of a society can instill within that society a set of core competences that improve the capacity of non-experts in machine learning to engage with machine learning outputs in a more knowledgeable way”.

Conclusion: Humans take three different roles when interacting with machine learning, consumers, makers, and learning experts. “A more data literate society will help each type of identified user to better fulfill their roles”.

How does what they're saying inform how we design interventions / feedback for people? I don’t think this helps at all since our goal is to make a more data literate society. If anything, our research will help prove their research.

Author: Jeremy Boy, Ronald A Rensink, Enrico Bertini, and Jean-Daniel Fekete

Title: A Principled Way of Assessing Visualization Literacy

Year: 2014

Venue: IEEE Transactions on Visualization and Computer Graphics

Aim: In this article, Item Response Theory (IRT) is used "in two ways: first, in a design phase, we evaluate the relevance of potential test items; and second, in an assessment phase, we measure users' abilities to extract information from graphical representations." The main goal "for this work is to design a series of tests that can help Information Visualization (InfoVis) researchers detect low-ability participants when conducting online studies, in order to avoid possible confounds in their data."

Conclusion: They conducted 4 different types of visualization surveys on Mturk. These included: two line graphs (LG1 and LG2), one bar chart (BC) and one scatterplot (SP). Each of these studies came to the same conclusion that they are most useful "for differentiating between examinees with relatively low abilities, but not so much for ones with high abilities."

How does what they're saying inform how we design interventions / feedback for people? This article's results shows that the average participant in their four studies was below average. If we can determine this source's credibility, and that their surveys were unbiased and error free, we can make the assumption that the average person is below average when it comes to comprehension of line graphs, bar charts, and scatterplots. This may be useful information when creating our feedback charts/visualizations. We may need to be mindful of that fact that the average person is not likely to comprehend a basic chart as well as we would have previously thought.

Author: Sukwon Lee, Sung-Hee Kim, Ya-Hsin Hung, Heidi Lam, Member, IEEE, Youn-ah Kang, and Ji Soo Yi, Member, IEEE

Title: How do People Make Sense of Unfamiliar Visualizations?: A Grounded Model of Novice's Information Visualization Sensemaking

Year: 2016

Venue: IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS, VOL. 22, NO.1

Link: http://www.cs.tufts.edu/comp/250VIS/papers/Lee2016.pdf

Aim: "The goal of this study is to investigate how people make sense of unfamiliar visualizations. In particular, we are interested in "novice users" that can be defined as users who have seen a particular type of visualization for the first time. For example, if one sees a parallel-coordinates plot for the first time, the person is a novice user for the parallel-coordinate plot. By focusing on observing novice users when they endeavor to make sense of unfamiliar visualizations, we try to understand the information visualization sensemaking activities. Sensemaking can be defined variously depending on the discipline [21, 22, 35, 36]. However, we refer to information visualization sensemaking as "conscious efforts to achieve understanding of how to interpret visual objects and underlying content in an information visualization" in this study."

Conclusion: "From our observation, we also found that there were mainly two ways to deal with the activity of floundering on visualization. The first was to give up making sense of the visualization. In this case, the participants exhibited confusion and superficially described objects that caught his/her eyes, and then finished the think-aloud session. In contrast, some participants made an effort to seek and construct a frame so that they would make sense of the visualization."

How does what they're saying inform how we design interventions / feedback for people?
This article comes to the conclusion that low level literacy participants are likely to give up and then complete the think-aloud session. Because low level literacy participants are more likely to give up, we need to come up with a feedback mechanism that would discourage them from giving up.

Author: Holly Rushmeier, Jason Dykes, John Dill, Peter Yoon

Title: Revisiting the Need for Formal Education in Visualization

Year: 2007

Venue: IEEE Computer Graphics and Applications

Link: http://cs.yale.edu/c2/images/uploads/HR20.pdf

Aim: "Careless production of visualizations lead to misinterpretation" and with "increasing decision making" based on data visualizations. With a growing range of students who need to "comprehend and organize large data in many areas outside the natural and physical sciences and engineering", would there be a need for education in this field? They also talk about if there was a need, what would need to be taught, what are the topics, who are the instructors, etc.

Conclusion: In creating a visualization course, there should be cross-disciplinary interaction. In the end, the paper concluded that having a need for education in data visualization is a need, but transitioned to the how aspect.

How does what they're saying inform how we design interventions / feedback for people? Nothing they say informs us how we design interventions or feedback, the only use I see for this paper is that it supports our research by discussing the need to make data visualizations easier to read and understand for the average person.

Author: Priti Shah and James Hoeffner

Title: Review of Graph Comprehension Research: Implications for Instruction

Year: 2002

Venue: Educational Psychology Review, Vol. 14, No. 1

Link:
https://deepblue.lib.umich.edu/bitstream/handle/2027.42/44452/10648_2004_Article_363437.pdf

Aim: "This article provides a set of guidelines for the presentation of graphs to students and considers the implications of graph comprehension research for the teaching of graphical literacy skills. Finally, this article discusses unresolved questions and directions for future research relevant to data presentation and the teaching of graphical literacy skills."

Conclusion: The the major principles of graph design implied by the research reviewed in this article- 1) Choose the format depending on the communication goal. 2) Use multiple formats to communicate the same data. 3) Use the "best" visual dimensions to convey metric information whenever possible. 4) Use animation with caution. 5) Reduce working memory demands. 6) Choose colors carefully. 7) The "third" dimension is okay unless precise metric information is needed. 8) Choose aspect ratio and data density (graph size) carefully. 9) Make graphs and text consistent.

How does what they're saying inform how we design interventions / feedback for people?
This article gives us a list of tips to follow when designing visualizations/graphs for feedback.

Author: Nesha Kodagoda, B L William Wong, Chris Rooney, Nawaz Khan.

Title: Interactive Visualization for Low Literacy Users: From Lessons Learnt To Design

Year: 2012

Venue: Literacy on the Margin CHI

Link:
http://delivery.acm.org/10.1145/2210000/2208565/p1159-kodagoda.pdf?ip=130.215.9.173&id=2208565&acc=ACTIVE%20SERVICE&key=7777116298C9657D%2E71E5F5E88B9A3E17%2E4D4702B0C3E38B35%2E4D4702B0C3E38B35&CFID=794083578&CFTOKEN=67171955&__acm__=1464879707_6ef23801611470be80fbd7566b23fe89

Aim: As the web grows with more information "whilist at the same time reducing face-to-face advice. This creates a challenge for low literacy users". The paper addresses "the problems low literacy users face when searching for information online" and "establishes a set of design principles for interfaces suitable for low literacy users".

Conclusion: Low literacy users have a tendency to read word-for-word, focus "narrowly on parts of the screen due to skipping chunks of text", "tend to go for early closure instead of differentiating and verifying the information found for correctness", and when lost in the search, struggle to recover and resume the search task. They take a trial-and-error approach. "LL users preferred the way information was presented (boxed), the flexibility to move index cards or clusters, use of Wizard to delete or mark information as important, visual cues, and finally the smooth transitions and less clutter due to the increase in white space".

How does what they're saying inform how we design interventions / feedback for people? It seems that low literacy users like clustering of data because of their tendency to read word by word. So **possibly when providing feedback, instead of data all over the place, it is clustered in a spot with relevant information around this clustered spot as well explaining the feedback.** *keep in mind the paper is about searching for pages on the internet, not really low literacy people getting tested on visualizations.

Author: Dawn E. Woodland, Linda F Szul

Title: Visualization Ability, Proofreading, and Color Configurations of a Computer Screen-Interactions and Implications

Year: 1999

Venue: Information Technology, Learning, and Performance Journal

Link:
http://search.proquest.com/docview/219837489/fulltext/EF93304F0B464DECPQ/1?accountid=29120

Aim: Examine the effect of color configuration of a video display terminal on the operator's ability to detect typographical errors in keyboarded copy. Also analyze the results after subjects were asked to proofread four documents containing embedded errors.

Conclusion: Results indicated that no statistically significant relationship existed between visualization ability and color configuration. However, there was a relationship between proofreading ability and visualization ability. The study also indicated that both high and low visuals proofread more accurately with dark text on a light background.

How does what they're saying inform how we design interventions / feedback for people? Assuming this article's results are accurate and unbiased, we can use their results to create better visualizations for both low and high level literate participants by creating visuals that have dark text on a light background. We can also be aware of the fact that there is a relationship between proofreading ability and visualization; however there is no known relationship between color configuration and visualization ability.

Author: Maria C. Velez-Rojas, Prof. Deborah Silver, and Prof. Marilyn Tremaine

Title: A Cognition-Based Framework for the Development of Visualization Literacy

Year: 2009

Venue:

Link: https://rucore.libraries.rutgers.edu/rutgers-lib/25955/

Aim: "The goal of this dissertation is to define an approach that can be used to determine the factors that make a visualization difficult to comprehend by certain individuals. This information is then used to test if training using this information helps individuals develop new and workable strategies for visualization analysis. In this dissertation we present an approach that is designed as a series of steps designed (1) to determine what cognitive abilities are correlated with comprehension of the visualization, (2) to identify visual properties that make a basic visualization difficult to comprehend and (3) to measure the effect of basic incremental training using these visual properties. "

Conclusion: "The main results from each step in the approach are listed below.
Step 1 : Cognitive Factors that Affect Visualization Comprehension

1. Visualization comprehension issues were found to affect even educated college students in the peak age range for cognitive skills development. Factors such as lack of formal education and age are likely to negatively intensify comprehension problems in diverse populations.
2. Significant gender differences were found in the accuracy of the answers given in the visualization test. However, no significant gender differences were captured by any of the psychometric tests in Study 1.
3. The strength of the correlation between the cognitive abilities and visualization questions was not constant across all visualization questions. The nature of the set of possible answers in some of the questions made them more difficult for individuals with lower, or in the case perceptual speed, higher skill levels.
4. The time participants spent analyzing a visualization question is not correlated with the accuracy of the visualization analysis (i.e., mental reconstruction of objects' shape and orientation). Individual differences and the strategies used to solve the problems may have contributed to the time differences.

Step 2: Visualization Comprehension, Visual Properties and Strategies

1. Significant differences in the accuracy of participants' answers were found between those with low and those with high levels of spatial skill, as measured by the Paper Folding Test.

2. Geometric characteristics of the visualized object (e.g., number of edges and surfaces of the 3D object) and visual properties (e.g., hidden edges in the 2D projections) in visualization questions were found to make visualization questions significantly more difficult to analyze for most participants with low spatial skill.

3. The visual information and the strategies used by novices and expert visualizers can be very different. It was found that participants with lower accuracy were not integrating the visual information provided by all the 2D projections and usually relied on one projection.

Step 3: Effect of Incremental Training on Visualization Comprehension

1. Incremental training improves viewers' visualization skill with only minimal training using a training strategy that is based on incremental difficulty of the visualization questions as a training strategy.

2. Participants at all levels of spatial skill improved after training in the incremental treatment. There were significant differences in accuracy between all levels of spatial skill."

How does what they're saying inform how we design interventions / feedback for people?
The conclusions/results this paper describes should be very useful when creating our visualizations and during analysis of our results. I think the most impactful conclusion made in this paper is the fact that participants at ALL levels (whether they have a high or low level literacy) improved after training in the incremental treatment. This shows that visualization tools, if used correctly, can help everyday people improve their visualization skills.

Author: Puripant Ruchikachorn, Klaus Mueller, Senior Member

Title: Learning Visualizations by Analogy: Promoting visual Literacy through Visualization Morphing

Year: 2015

Venue: IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS, VOL. 21, NO. 9

Link: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=7061477

Aim: The paper seems to argue that unfamiliar visualizations seem to be understood better by "demonstrating an unfamiliar visualization method by linking it to another more familiar one". Essentially, an unfamiliar visualization is learned through a method that consist of a "step by step transformation from another visualization method".

Conclusion: It seems that morphing familiar graphs into the once unfamiliar graphs have increased better understanding of unfamiliar visualizations. Participants had better data and visual understanding with the morphing method than

How does what they're saying inform how we design interventions / feedback for people? Maybe when we do adaptations of the charts to improve data literacy, we morph the original graph into the newly adapted graph. I can't really think of an idea of morphing feedback or why we would ever morph feedback since the point of feedback should already be easy to understand.

Author: Susan N. Friel, Frances R. Curcio and George W. Brigh

Title: Making Sense of Graphs: Critical Factors Influencing Comprehension and Instructional Implications

Year: 2001

Venue: Journal for Research in Mathematics Education Vol. 32, No. 2

Link: http://www.jstor.org/stable/749671

Aim: "Our purpose in this article is to bring together key ideas from various perspectives, going beyond several earlier reviews of the literature (DeSanctis, 1984; Jarvenpaa & Dickson, 1988; MacDonald-Ross, 1977; Malter, 1952), to identify critical factors that appear to influence comprehension of graphs and to suggest instructional implications. In the first part of the article, we define what we mean by graphs and provide an analysis of the structure of graphs and tables. Next, we define graph comprehension. We then address several of the critical factors: purposes for using graphs, task characteristics, discipline characteristics, and reader characteristics."

Conclusion: Questioning (i.e., question asking and question posing) is an important aspect of comprehension. Researchers have proposed that question-asking is a fundamental component of cognition and plays a central role in the comprehension of text (Graesser, Swamer, Baggett, & Sell, 1996). Low-level questions "address the content and interpretation of explicit material whereas deep questions involve inference, application, synthesis, and evaluation" (p. 23). In comprehending text, readers need to be able to ask questions that help them identify gaps, contradictions, incongruities, anomalies, and ambiguities in their knowledge bases and in the text itself. Teachers need to develop a framework within which to think about which questions to ask. Such a framework for question-asking is relevant for considering comprehension of graphs."
"For instruction on graphs, one needs to consider several elements: for example, sequencing of types of graphs, developing understanding of data reduction, and developing various aspects of graph sense."

How does what they're saying inform how we design interventions / feedback for people?

Assuming these conclusions are accurate, we could say that it is important for people to ask questions when attempting to comprehend visuals. I think we may be able to somewhat incorporate the questions aspect if we asked them questions before and/or after each graph. This is not exactly what the article suggests we do because it says that people learn better if they ask questions, rather than being asked questions. However, I think that it would help the participants, at least a little bit, if we were to ask them “checkpoint” questions to make sure they are on the right track. Also, we would tell them if they got the answer correct immediately, and if they didn’t get the right answer we would indicate the correct one for them.

Author: Lars Grammel, Melanie Tory, Margaret-Anne Storey

Title: How Information Visualization Novices Construct Visualizations

Year: 2010

Venue: IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS, VOL. 16, NO. 6

Link: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=5613431

Aim: "Our research goal was to explore how InfoVis novices construct visualizations, and specifically to understand the processes used in mapping data elements to visualization attributes. We define *InfoVis Novices* as those who are not familiar with information visualization and visual data analysis beyond the charts and graphics encountered in everyday life."

Conclusion: "We found that there were three main activities in the iterative visualization construction process; data attribute selection, visual template selection, and visual mapping specification (4.1). The major barriers were translating questions into data attributes, designing visual mappings that support answering these questions, and interpreting the visualizations (4.2). The participants often omitted parts of the visualization specification (4.3), and used simple heuristics or preferred visualizations they were already familiar with, such as bar, line and pie charts.(4.4)."

How does what they're saying inform how we design interventions / feedback for people?
According to this paper, the three most difficult tasks for participants in this study (and potentially other everyday people as well) was that they had to translate questions into data attributes, design visual mappings that support answering these questions and interpret the visualizations. By knowing that these are the potential problems participants will encounter, we can try to avoid these problems through the use of helpful visual adaptations. Although, it says in this paper that common visualizations like bar charts, line graphs and pie charts are preferred by participants because they are familiar with them, I

hope that with this new knowledge of the barriers/challenges they will face, we can help them better comprehend the visualizations.

Author: Stephen M. Kosslyn

Title: Understanding Charts and Graphs

Year: 1989

Venue: Applied Cognitive Psychology, Vol 3, 185-226

Link: https://courses.cs.washington.edu/courses/cse590d/03au/kosslyn-1-up.pdf

Aim: The main goal of this paper has to do with the development of “acceptability principles” and how they are used to diagnose problems with displays. Two principles bear on the process of discriminating marks: 1) Adequate discriminability - “variations in mark must be great enough to be easily noted.” 2) perceptual distortion - “marks should be used that are perceived veridically.” “The most important laws can be summarized by four general principles:” 1. “Good continuity” 2. “Proximity” 3. “Similarity” 4. “Good Form”

Conclusion: “The present analytic scheme is designed to reveal features of displays that result in their being difficult to understand. This scheme depends on looking very carefully at a display, and generating a detailed description of it at three levels of analysis. At each level we consider the nature and role of the background, framework, specifier, and labels, and we consider the interrelations among these constituents. Whenever we have difficulty generating the description, we consider whether one of the acceptability principle has been violated.”

How does what they're saying inform how we design interventions / feedback for people? Using the information in this paper, we can potentially create easy to understand graphs and visualizations. By following the “acceptability principles” we can be almost certain that our graph will make sense to participants when they read the graphs/visualizations.

Author: Konrad J. Schonborn, Trevor R. Anderson

Title: The importance of visual literacy in the education of biochemist

Year: 2006

Venue: Biochemistry and Molecular Biology Education, Vol. 34, NO.2

Link: http://onlinelibrary.wiley.com/doi/10.1002/bmb.2006.49403402094/full

Aim: "In this study, we discuss the nature and importance of visualization in biochemistry education and argue that students should be explicitly taught visual literacy and the skills for using visualization tools as essential components of all biochemistry curricula.**"**

Conclusion: "Based on the above commentary, an extensive examination of the literature, and on our own research findings, we have identified 10 fundamental guidelines [24] for teaching and learning with ERs that have arisen out of our thinking about the pedagogical implications of visualization in biochemistry education." The fundamental guidelines are as follows:

1) Take Cognizance of Current Theories on How Individuals Learn from, and Visualize, ERs (External representations)
2) Address the Key Factors Affecting Students' Ability to Visualize ERs
3) Acknowledge the Importance of Pedagogical Content Knowledge (PCK) in Visualization
4) Make the Conceptual Knowledge Depicted by ERs Explicit to Students
5) Ensure Knowledge of the Visual Language and Conventions Used by ERs
6) Make Students Aware of the Limitations of Each ER
7) Foster a Multiple Representations Approach to the Visualization of ERs
8) Empower Students with the Necessary Skills Needed to Process Biochemical ERs
9) Develop Students' Metacognitive Processing Skills
10) Use Learner-generated ERs to Help Students Visualize Biochemical Phenomena

"In addition to the guidelines for teaching and learning presented above, it is also essential that researchers investigate the *effectiveness* of ERs used in teaching and

learning. In this regard, our own research [10, 24, 26] has shown that the nature of the ER itself can also have a large influence on the visualization process, and an ER that is easily interpreted by an instructor is not necessarily interpreted as easily by a learner. Thus there is an urgent need to screen all ERs for their effectiveness as teaching and learning tools in case they cause more harm than good. Therefore, formal guidelines for the *effective design* of biochemistry ERs should be given urgent attention, a topic that will be the focus of a future study."

How does what they're saying inform how we design interventions / feedback for people?
Based on this article, we need to follow the "fundamental guidelines" listed above (and in the article) in order to enhance our interventions/feedback for people.

Author: Michelle H. Wilkerson, Alfredo Bautista, Roger G. Tobin, Barbara M. Brizuela, Ying Cao

Title: More than meets the eye: patterns and shifts in middle school mathematics teachers' descriptions of models

Year: 2016

Venue: J Math Teacher Educ. Springer Science+Business Media Dordrecht

Link:
https://scholar.google.ca/citations?view_op=view_citation&hl=en&user=twy43yEAAAAJ&cstart=20&citation_for_view=twy43yEAAAAJ:4DMP91E08xMC

Aim: 9 middle school teachers with different academic backgrounds were asked to collect data and construct a model of cooling liquid. The features and purpose of each model was documented. Teachers may have multiple understandings of models, but which model serves to be the best? What should be represented in a model? What quantitative information should a model have? Basically the paper talks about what mathematics teachers "attend to when describing what constitutes a model".

Conclusion: In the research, models were justified using features (any quality or property of a representation) and purpose (any intended or potential role). "Teachers focused primarily on features of models: such as that they should include data, include important trends, be visual, and be easily interpretable". Some argue that models "should be contextualized and reflect important aspects of the situation".

How does what they're saying inform how we design interventions / feedback for people?
When we design interventions or feedback we should focus on the features and purpose. We should think about whether or not the features are useful, whether there is a lack of feature, and whether or not the purpose is clear.

Author: Vasiliki Laina, Michelle Wilkerson

Title: Distributions, Trends, and Contradictions: A Case Study in Sensemaking with Interactive Data Visualizations.

Year: 2016???

Venue: Proceedings of the 11th International Conference of the Learning Sciences.

Link:
https://scholar.google.ca/citations?view_op=view_citation&hl=en&user=twy43yEAAAAJ&cstart=20&citation_for_view=twy43yEAAAAJ:aqlVkmm33-oC

Aim: Students leverage "contextual knowledge to explain patterns they noticed, often supplementing their own observations of the actual phenomenon" to make sense of representations. Data visualizations can be hard to understand and with a growing support of representing information through data visualizations, the paper analyzes how young learners "interpreted an interactive visualization". This can lead to more research of data visualization literacy.

Conclusion: Students report data visualizations through distribution and trends overtime. "

"We found that both participants interpreted the data provided in an interactive visualization of energy consumption by different fuel types in two potentially contradictory ways: as 'relative measures' describing distribution in terms of percentages, and as 'absolute quantities' describing total increases or decreases in energy consumption over time. These dual interpretations created conflicts between the participants' understanding, the data, the representation, and their knowledge of actual energy consumption trends."

How does what they're saying inform how we design interventions / feedback for people?
Using this research, when we design interventions or feedback, we should make sure that there is a mutual interpretation of all parties to prevent contradictory interpretations. The cause of the contradiction was because of how the visualization was represented.

Author: Michelle Wilkerson-Jerde, Elsa Head

Title: Designing Data Visualizations to Promote Mathematics Learning and Identity Development.

Year:

Venue:

Link:
https://scholar.google.ca/citations?view_op=view_citation&hl=en&user=twy43yEAAAAJ&cstart=20&citation_for_view=twy43yEAAAAJ:_kc_bZDykSQC

Aim: 7th grade graders analyzed and designed visualizations of public city data. They analyzed the "students' engagement with math content and mathematical agency" as well as identifying support. The point of the research was to what extent the students engaged in these factors.

Conclusion: "Data visualization activity holds potential to engage students in deep and meaningful mathematical exploration. However, more work needs to be done to identify what curricular supports, materials, and facilitator can help those student groups who fail to engage in deep mathematical exploration".

How does what they're saying inform how we design interventions / feedback for people?
The paper doesn't really help tell us how to design. More like telling us that data visualization is important since it helps students learn...

Author: Drew Skau and Robert Kosara

Title: Arcs, Angles, or Areas: Individual Data Encodings in Pie and Donut Charts

Year: 2016

Venue: Eurographics Conference on Visualization (EuroVis). Vol. 35 NO. 3

Link: http://kosara.net/publications/Skau-EuroVis-2016.html

Aim: "While angles are often mentioned when discussing pie and donut charts, there are three retinal variables that encode data: the angle, the area of the circle wedge, and the length of the segment on the circle (Figure 2). Which of these encodings do people read, and how important is their combination? Which can be left out without doing damage to accuracy?"

Conclusion: "...we designed a study to separate the three visual cues and compare how well each of them would do on its own (Section 3). Based on this, we then designed a second study to measure the difference between pie and donut charts and the impact of the size of the donut hole (Section 4). **Both studies point to angle being less important than arc and area."**

"The results show that **all three visual cues are important**, but that **arc length** in particular seems to provide **important** information. Angle is clearly not a significant bearer of information in pie charts, and in particular the central meeting point of the circle segments does not appear to be crucial. Donut charts thus appear to be no worse than pie charts"

How does what they're saying inform how we design interventions / feedback for people?
Based on their studies, we can assume that most everyday people perceive donut charts just as accurately as pie charts. This is because the angle in the center of the chart is not a significant bearer of information in pie charts. The most crucial visual cue to give someone is arc length. When designing feedback mechanisms for everyday people, we can choose to either display a pie chart or donut chart without worrying about affecting their perception of the information.

Author: Robert Kosara and Drew Skau

Title: Judgment Error in Pie Chart Variations

Year: 2016

Venue: Eurographics Conference on Visualization (EuroVis)

Link: http://kosara.net/publications/Kosara-EuroVis-2016.html

Aim: "We tested four variations on the basic pie chart to measure their effect on error in reading." The four charts included are: "base pie chart, chart with larger slice, exploded pie, elliptical pie, and square pie."

Conclusion: **"**We find that even variants that do not distort central angle cause greater error than regular pie charts. Charts that distort the shape show the highest error."
"Regarding the qualitative predictions, we find that our results largely fit them:
• The **larger slice leads to** systematic **overestimation** over almost the entire range of values.
• **The exploded pie chart shows higher error**, which we did not expect. Perhaps the gap between the two slices adds a level of distraction that causes higher error.
• **The ellipse yields much higher error** than the circle, as expected.
• Likewise, the **square produces larger error**, just as expected. Interestingly, the ellipse actually leads to more error than the square, which we did not expect."
"Design choices common in infographics cause considerable distortion. The worst offenders in our study were the ones where the shape of the "pie" was no longer a circle. We recommend that all such designs be avoided in favor of simple pie and donut charts."

How does what they're saying inform how we design interventions / feedback for people?
According to this study, we should avoid "pie" charts that are no longer in a circle. In this study, they concluded that both ellipse and square shaped "pie" charts produced a larger error that expected. Also, they concluded that ellipse shaped pie charts are far worse than square shaped pie charts. When creating feedback mechanisms for everyday people, we should try to avoid distorting the shape of the pie/donut chart if at all possible.

Author: Helmut Doleisch, Martin Gasser, Helwig Hauser

Title: Interactive Feature Specification for Focus+Context Visualization of Complex Simulation Data

Year: 2003

Venue: Joint EUROGRAPHICS - IEEE TCVG Symposium on Visualization

Link: http://cis.ofai.at/~martin.gasser/papers/p239-doleisch.pdf

Aim: "In this paper we present a framework for flexible and interactive specification of high-dimensional and/or complex features in simulation data. The framework makes use of multiple, linked views from information as well as scientific visualization and is based on a simple and compact feature definition language (FDL). It allows the definition of one or several features, which can be complex and/or hierarchically described by brushing multiple dimensions (using non-binary and composite brushes)."

Conclusion: "The result of the specification is linked to all views, thereby a focus+context style of visualization in 3D is realized. To demonstrate the usage of the specification, as well as the linked tools, applications from flow simulation in the automotive industry are presented."

How does what they're saying inform how we design interventions / feedback for people? We will use this source as our "inspiration" for the focus+context feedback mechanism.

Author: John Lamping, Ramana Rao, and Peter Pirolli

Title: A Focus+Context Technique Based on Hyperbolic Geometry for Visualizing Large Hierarchies

Year: 1995

Venue: CHI'95 MOSAIC Of CREATIVITY

Link: http://dl.acm.org/citation.cfm?id=223956

Aim: "Information Visualization research has explored the application of interactive graphics and animation technology to visualizing and making sense of larger information sets than would otherwise be practical [11]. One recurring theme has been the power of focus+Context techniques, in which detailed views of particular parts of an information set are blended in some way with a view the of the overall structure of the set. In this paper, we present a new technique, called the hyperbolic browser, for visualizing and manipulating large hierarchies."

Conclusion: "Hyperbolic geometry provides an elegant solution to the problem of providing a focus+Context display for large hierarchies. The hyperbolic plane has the room to layout large hierarchies, and the Poincare map provides a natural, continuously graded, focus+Context mapping from the hyperbolic plane to a display. The hyperbolic browser can handle arbitrarily large hierarchies, with a context that includes as many nodes as are included by 3d approaches and with modest computational requirements. Our evaluation study suggested this technique could be valuable..."

How does what they're saying inform how we design interventions / feedback for people?
We will use this source as our "inspiration" for the focus+context feedback mechanism.

Author: John Stasko and Eugene Zhang

Title: Focus+Context Display and Navigation Techniques for Enhancing Radial, Space-Filling Hierarchy Visualizations

Year: 2000

Venue: Proceedings of the IEEE Symposium on Information Visualization

Link: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=885091

Aim: "...allow viewers to examine the small items in detail while providing context within the entire information hierarchy."

Conclusion: "We have introduced three visualization/navigation techniques to help viewers explore small, indistinguishable portions of radial, space-filling displays of hierarchies. The techniques always keep some overview of the entire hierarchy present to preserve context, and they utilize smooth, animated transitions in state to help people track changes in focus."

How does what they're saying inform how we design interventions / feedback for people?
We will use this source as our "inspiration" for the focus+context feedback mechanism.

Hanging Sources

▫Bum chul Kwon, Brian Fisher, Ji Soo Y. iVisual Analytic Roadblocks for Novice Investigator. 2011. IEEE Symposium on Visual Analytics Science and Technology.
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6102435
Heidi Lam. A Framework of Interaction Costs in Information Visualization. 2008. IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS, VOL. 14, NO. 6.
http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4658124

▫ Catherine Plaisant. The Challenge of Information Visualization Evaluation. 2004. IEEE Proc. of AVI.
http://hcil2.cs.umd.edu/trs/2004-19/2004-19.pdf

▫M. A. Borkin. What Makes a Visualization Memorable?. IEEE Transactions on Visualization and Computer Graphics (Proceedings of InfoVis 2013), 2013.
http://vcg.seas.harvard.edu/files/pfister/files/infovis_borkin-128-camera_ready_0.pdf?m=1381515849

Potential Sources

Peebles Sources

Author: David Peebles, Nadia Al.

Title: Expert interpretation of bar and line graphs: the role of graphicacy in reducing the effect of graph format

Year: 2015

Venue: Front Psycol; 6: 1673.

Link: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4626626/

Aim: Expect interpretations of bar graphs and line graphs are roughly the same unlike novice interpretations who tend to do worse with a change of graph format. The paper discusses the processes that the experts used to achieve their interpretation, and whether or not interpretation is affected by relative size of patterns formed by data.

Conclusion: "The experiment has revealed that although experts can interpret bar and line graphs equally well, the processes by which they interpret them are affected by the format of the graph and also by the relative sizes of the effects in the data (irrespective of format)". "The analyses above demonstrated that graph format has no significant effect on the number of main or interaction effects identified by experts or the order in which they are interpreted". Experts also displayed no patterns in their processes of interpreting data.

How does what they're saying inform how we design interventions / feedback for people? Seems like experts do not really need help with interpreting data visualizations. They do not have any patterns to exploit that we could have used to design interventions, etc.

Author: Peebles, David.

Title: *Strategy and pattern recognition in expert comprehension of 2 × 2 interaction graphs.*

Year: 2013

Venue: Cognitive Systems Research, 24. pp. 43-51. ISSN 1389-0417

Link: http://eprints.hud.ac.uk/16214/

Aim: The paper "provides an account of the strategic processes that control comprehension, and makes explicit what underlies the differences between expert and novice performance".

Conclusion: **"**novices' interpretations are often limited to qualitative descriptions of differences between conditions and can be skewed by the different Gestalt principles of perceptual organisation" ". Specifically, line graphs users are influenced to attend to the legend variable while bar graph users attend to the two IVs "

How does what they're saying inform how we design interventions / feedback for people? Establishing patterns "account for the speed and sequential order of expert interpretations". This is how experts are able to interpret data visualizations and get something out of it. **If we design interventions or feedback that allows people to recognize patterns of the graphs, it can go a long way for novice interpretation of data visualizations.**

Author: Ali, Nadia and Peebles, David.

Title: *The Effect of Gestalt Laws of Perceptual Organization on the Comprehension of Three-Variable Bar and Line Graphs.*

Year: 2013

Venue: Human Factors: The Journal of the Human Factors and Ergonomics Society, 55 (1). pp. 183-203. ISSN 0018-7208

Link: http://eprints.hud.ac.uk/19084/

Aim: People interpret line graphs wrong because of Gestalt's principle of perceptual organization. There is a new design for a line graph that makes it easier for novice interpretation. The paper introduces this new design and tests to see if there are notable performances.

Conclusion: "factors such as visual clutter, the strength of the visual effect introduced, and the level of user unfamiliarity" contribute to performance of data interpretation.

"What is needed therefore is a modified graphical representation where the perceptual features relating the pattern to both independent variables are more evenly balanced. Additional constraints on any design are that it should not look too unusual or unfamiliar to users, should not over-complicate the diagram visually, and ideally should allow the same process by which readers effortlessly relate the pattern to the legend variable be employed in relating the pattern to the x axis variable. Our proposed solution to this problem is a novel design that, rather than using features that associate two locations by explicitly drawing a line between them, uses the same colour feature used for the legend variable to associate the plot points to the x axis."

Key points

- Gestalt principles of perceptual organisation are regarded as playing a crucial role in the visual processing of graphical representations.
- It has been assumed that students can interpret both bar and line interaction graphs equally well and that the benefits of line graphs enjoyed by experts can readily be acquired by novices.
- We have demonstrated the limitations of this assumption and shown that a large proportion of undergraduate students struggle to interpret line graphs even at an elementary level.
- The "colour match" graph we have developed combines the benefits of both line and bar graphs.

How does what they're saying inform how we design interventions / feedback for people? Seems like color coding feedback or intervention can help novice get a better interpretation for data visualization. **Apply Gestalt's principle when designing interventions / feedback!**

D. Peebles, D. Ramduny-Ellis, G. Ellis, and J. V. H. Bonner. The influence of graph schemas on the interpretation of unfamiliar diagrams. Technical report, School of Human and Health Sciences. University of Huddersfield, UK, 2013.

Pruned Sources

▫ Sung-Hee Kim, Ji Soo Yi, Niklas Elmqvist. Oopsy-Daisy: Failure Stories in Quantitative Evaluation Studies for Visualizations. Proceedings of the Fifth Workshop on Beyond Time and Errors: Novel Evaluation Methods for Visualization Pages 142-146. 2014
http://dl.acm.org/citation.cfm?id=2669576

▫ Aritra Dasgupta, Jorge Poco, Yaxing Wei, Robert Cook, Enrico Bertini, and Claudio T. Silva, Fellow, IEEE. Bridging Theory with Practice: An Exploratory Study of Visualization Use and Design for Climate Model Comparison. IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS, VOL. 21, NO. 9, SEPTEMBER 2015
http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=7061479

▫ Sabrina Bresciani and Martin J. Eppler. The Risks of Visualization. ICA Working Paper # 1/2008, February 2008.
http://www.riskvisualizations.com/uploads/4/9/7/5/49758511/bresciani-eppler-risks-visualization-wpaper-08_(1).pdf

▫A. K. M. Zahiduzzaman, Mohammed Nahyan Quasem, Mridul Khan, Rashedur M Rahman. Spatial Data Mining on Literacy Rates and Educational Establishments in Bangladesh. Proceedings of 13th International Conference on Computer and Information Technology (ICCIT 2010) 23-25 December, 2010, Dhaka, Bangladesh.
http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5723890&tag=1

▫ A Taxonomy of Clutter Reduction for Information Visualisation. Geoffrey Ellis, Alan Dix. 2007. IEEE Transactions on Visualization and Computer Graphics (Volume:13 , Issue: 6).
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4376143

Template

Author:

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Aim:

Conclusion:

How does what they're saying inform how we design interventions / feedback for people?