A Heuristic Approach to Value-Driven Evaluation of Visualizations

Emily Wall, Meeshu Agnihotri, Laura Matzen, Kristin Divis, Michael Haass, Alex Endert, and John Stasko
Evaluating the utility of visualizations is difficult
Value of Visualization

• Move beyond ability to support (just) question-answering
  
  • Often evident in benchmark task-focused user studies

• Assess broader, more holistic benefits that communicates "big picture" importance and context of data
Value of Visualization

\[ V_{\text{value}} = T_{\text{ime}} + I_{\text{nsight}} + E_{\text{ssence}} + C_{\text{onfidence}} \]
Value of Visualization

Value = Time + Insight + Essence + Confidence

Ability to minimize the total time needed to answer a wide variety of questions about the data
Value of Visualization

\[ V_{value} = T_{ime} + I_{nsight} + E_{ssence} + C_{onfidence} \]

Ability to spur and discover **insights** or insightful questions about the data
Value of Visualization

\[ V_{\text{value}} = T_{\text{ime}} + I_{\text{nsight}} + E_{\text{ssence}} + C_{\text{onfidence}} \]

Ability to convey an overall \textit{essence} or take-away sense of the data
Value of Visualization

\[ \text{Value} = \text{Time} + \text{Insight} + \text{Essence} + \text{Confidence} \]

Ability to generate confidence and trust about the data, its domain and context.
Value of Visualization

\[ V_{\text{value}} = T_{\text{ime}} + I_{\text{nsight}} + E_{\text{ssence}} + C_{\text{onfidence}} \]

Goal: Operationalize this conceptual approach
Design of the Methodology
1. Literature Review
1. Literature Review

2. Four Brainstorm Sessions
1. Literature Review

2. Four Brainstorm Sessions

3. Workshop

- Preliminary Vis Evaluation
- Refine Heuristics
1. Literature Review
2. Four Brainstorm Sessions
3. Workshop
   - Preliminary Vis Evaluation
   - Refine Heuristics
4. Affinity Diagram
1. Literature Review
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   - Preliminary Vis Evaluation
   - Refine Heuristics
4. Affinity Diagram
   - Vis Evaluation
   - Refine Heuristics
5. Testing
Hierarchical Value Framework

4 high-level components

2-3 mid-level guidelines

1-3 low-level heuristics

21 total heuristics
| Insight | The visualization facilitates answering questions about the data | The visualization exposes individual data cases and their attributes  
The visualization facilitates perceiving relationships in the data like patterns & distributions of the variables  
The visualization promotes exploration of relationships among different aggregation levels of the data  
The visualization helps generate data-driven questions  
The visualization helps identify unusual or unexpected, yet valid, data characteristics or values  
The visualization provides useful interactive capabilities to help investigate the data in multiple ways  
The visualization shows multiple perspectives about the data  
The visualization uses an effective representation of the data that shows related and partially related data cases |
| Time | The visualization affords rapid parallel comprehension for efficient browsing | The visualization provides a meaningful spatial organization of the data  
The visualization provides key characteristics of the data at a glance  
The interface supports reorganizing the visualization by the data’s attribute values  
The visualization supports smooth transitions between different levels of detail in viewing the data  
The visualization avoids complex syntactic querying by providing direct interaction |
| Essence | The visualization provides a big picture perspective of the data | The visualization provides an effective, comprehensive and accessible overview of the data  
The visualization presents the data by providing a meaningful visual schema  
The visualization facilitates generalizations and extrapolations of patterns and conclusions  
The visualization helps understand how variables relate in order to accomplish different analytic tasks |
| Confidence | The visualization helps avoid making incorrect inferences | The visualization uses meaningful and accurate visual encodings to represent the data  
The visualization avoids using misleading representations  
The visualization promotes understanding data domain characteristics beyond the individual data cases and attributes  
If there were data issues like unexpected, duplicate, missing, or invalid data, the visualization would highlight those issues |
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Insight

The visualization provides opportunities for serendipitous discoveries
Insight

• The visualization provides useful interactive capabilities to help investigate the data in multiple ways

• The visualization shows multiple perspectives about the data

• The visualization uses an effective representation of the data that shows related and partially related data cases

• The visualization provides opportunities for serendipitous discoveries
Methodology

• Raters: people with substantial data visualization + domain knowledge

• 7-point likert ratings + n/a

• Scores averaged so each guideline & component counted equal

• Scope: Interactive visualizations
$V = T + I + E + C$
Assessing the Methodology
• 12 male, 3 female

• 6 researchers, 8 professors, 1 software engineer

• 7-30 years of experience (mean 14)
• Interactive

• Undergraduate course project

• US college dataset
Vis B
Vis C
### Insight

#### The visualization facilitates answering questions about the data

- The visualization exposes individual data cases and their attributes
- The visualization facilitates perceiving relationships in the data like patterns & distributions of the variables
- The visualization promotes exploration of relationships among different aggregation levels of the data

#### The visualization provides a new or better understanding of the data

- The visualization helps generate data-driven questions
- The visualization helps identify unusual or unexpected, yet valid, data characteristics or values

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Inter-Rater Reliability

• Mean for each vis on each heuristic

• Results:
  • Vis A: $r = 0.68$, $t(13) = 3.33$, $p < 0.01$;
  • Vis B: $r = 0.75$, $t(13) = 4.06$, $p < 0.01$;
  • Vis C: $r = 0.54$, $t(13) = 2.29$, $p < 0.05$;
Inter-Rater Reliability

• Component-level analysis

• Results:
  • Insight: $r = 0.56$, $t(13) = 2.46$, $p < 0.05$;
  • Confidence: $r = 0.55$, $t(13) = 2.40$, $p < 0.05$;
  • Essence: $r = 0.49$, $t(13) = 2.03$, $p = 0.06^*$;
  • Time: $r = 0.58$, $t(13) = 2.55$, $p < 0.05$;
• Average confidence in heuristic: $3.22 \pm 0.70$

• None had an average confidence < 3

• Confidence rating of 1 given to a total of 5 heuristics
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“The visualization promotes exploration of relationships among different aggregation levels of the data” between individual data cases as well as different groupings of data cases”
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Discussion
Discussion

• Subjective interpretation of heuristics

• 5 raters

• Independence of components
Applications

• Grading visualization course projects

• Formative design feedback

• Low-cost evaluation in academic or commercial settings
VisValue.org

Thank you!

Value-Driven Visualization Evaluation

The V3T Methodology for Measuring the Value of a Visualization

Description

Having big visualizations is complex. We have developed a value-driven methodology called V3T to help researchers, designers, and practitioners determine the value of visualizations. This site contains links to the research papers describing the methodology, supplemental material about the study, and materials available for download so that others can use the methodology.

Materials

To conduct an evaluation of a visualization using our V3T Methodology, we provide the following materials:

1. Process: Fill out our request form to receive a set of materials.
2. Project: Download and review the project materials.
3. Materials: Use the materials to conduct an evaluation of the visualization.

Next, recruit participants to conduct the study. Each participant should select a description of the visualization and rate it on a scale of 1 to 5. Each participant should also rate the visualization on a scale of 1 to 5. The results should be compiled to determine the value of the visualization.

Each participant will fill out one V3T survey for every visualization being evaluated. Once each participant has completed the survey, the scores from the participants will be compiled to determine the value of the visualization.