Countering Cognitive Biases in Maps based on Pragmatic Communication

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Map not to scale 😊
Maps

- Semantically rich: Wealth of spatial information
- However: People frequently read out information which is false or inadequate for a given task

Map interpretation is subject to cognitive biases

→ What does this mean?
→ What are pragmatic approaches to deal with it?
«Maps are more truthful than first-hand experiences»

Even experienced travellers interpret schematic maps in a metric way

(Guo, 2011; Raveau et al. 2014)

→ Possible effect: Under-/overestimation of distances
«Political borders are perceived as physical borders»

\[ EP(x, A) < EP(x, B) \]
\[ \text{dist}(x, A) = \text{dist}(x, B) \]

- Possible Effect: Map-based disaster warnings might be ineffective

\[ EP(x_1, A) > EP(x_2, A) \]
\[ \text{dist}(x_1, A) = \text{dist}(x_2, A) \]

x = Source of danger (e.g., earthquake), A, B = Cities
EP (x, A) = Estimated probability of x affecting A

Experimental results shown by Mishra and Mishra (2010)
Towards a Bias Model for Map Interpretation

- Idea: Separation of Representation and Information
- Representation contains:
  - Intended information (e.g., Mercator Proj. → Angle)
  - Unintended information (e.g., Mercator Proj. → Distances, Area)
- Bias occurs if unintended information is (unconsciously) given preference over intended information

<table>
<thead>
<tr>
<th>Example</th>
<th>Intended</th>
<th>Unintended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercator Map</td>
<td>Greenland is NW of Africa</td>
<td>Greenland is the size of Africa</td>
</tr>
<tr>
<td>Tube Map</td>
<td>Stations Victoria and Green Park are connected</td>
<td>dist(Victoria, Green Park) = 3x dist(Green Park, Hyde Park Corner)</td>
</tr>
</tbody>
</table>
Tentative Formal Model

- Content C: Set of information items that can be extracted from a given representation R. \( C(R) = \{i_1, i_2, \ldots, i_n\} \)
- Weight: Each information item has a weight equal to cognitive ease of extraction process. \( w(c_i) \)
- Intended Info: \( I = \{i_1, i_2, \ldots, i_l\} \subseteq C \)
- Unintended Info: \( U = \{i_{l+1}, i_{l+2}, \ldots, i_n\} \subseteq C \) \( C = I \cup U \)

- Task-relevant representation = \( C(R') \subseteq C(R) \)
- Task-relevant / intended = \( T_i = I \cap C(R') \)
- Task-relevant / unintended = \( T_u = U \cap C(R') \)
General Bias

\[
\sum_{k=1}^{l} w(i'_{k}) > \sum_{k=1}^{m} w(i_{k})
\]

where \(i' \in U\) and \(i \in I\)

Task-dependent Bias

\[
\sum_{k=1}^{l} w(j'_{k}) > \sum_{k=1}^{m} w(j_{k})
\]

where \(j' \in T_u\) and \(j \in T_i\)
Task at hand narrows down the relevant information

Tube Map intended for figuring out transport connections
→ Only topology needs to be preserved
Mercator Map intended for (ship) navigation
→ Angles must! be preserved.
Bias Mitigation I: Change in Representation

Bank - Monument

1933

1960

2014

Bank – Cannon Street

Walk to Monument → Take G/Y Line

Walk to Mansion Street

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Change in representation can influence the ease of information extraction

Ex: Make length comparison more difficult

a) Optical Illusion

b) Animation
Bias Mitigation II: Increasing Awareness
Conclusions

- Formal Model of Bias needs to distinguish:
  - Intended from unintended information
    → Distinction can be drawn for maps based on reference systems
  - Information extraction weights (based on cognitive ease)
  - Task relevant information

- Pragmatic Counter Measures.
  - Can be based on formal model and involve two measures:
    - Change in Representation
    - Increase Awareness
References


