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Countering Cognitive Biases in Maps based on Pragmatic Communication

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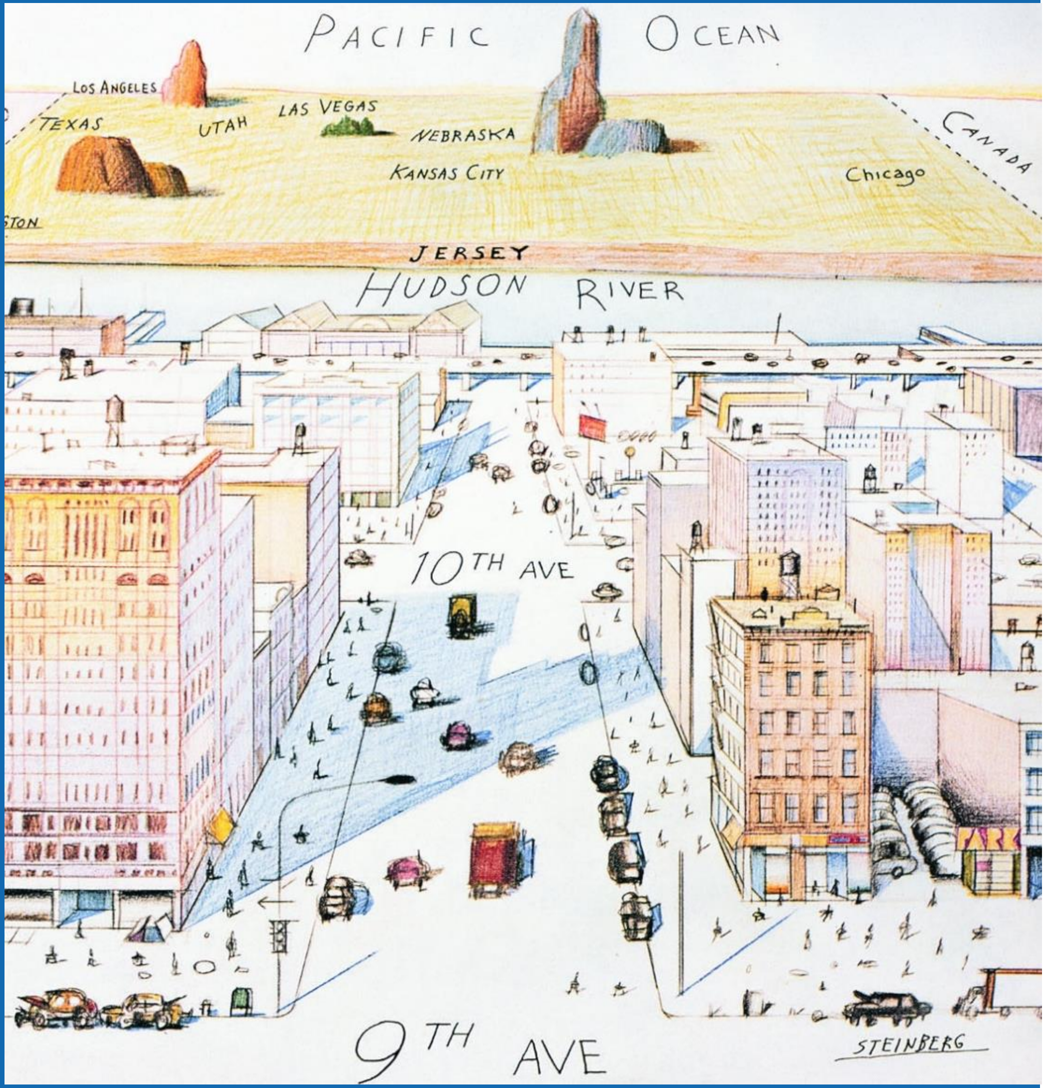


Map not to scale ☺

Maps

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

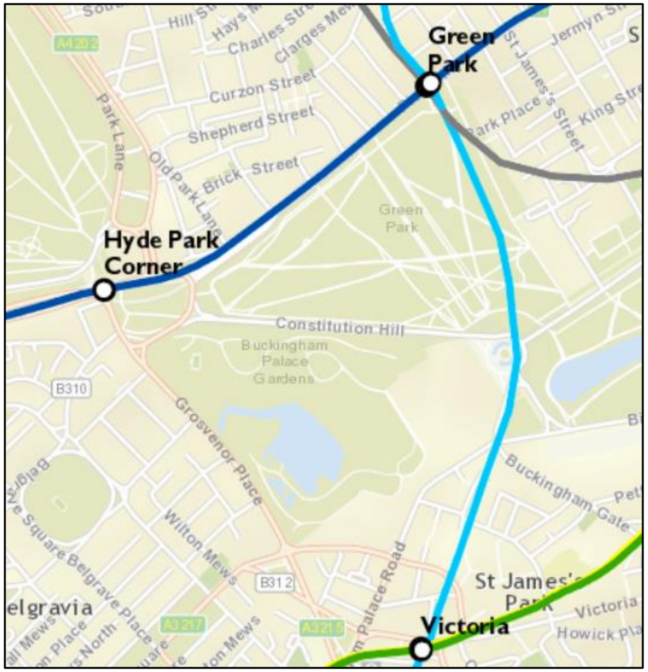
Map interpretation is subject to cognitive biases

→ What does this mean?

→ What are pragmatic approaches to deal with it?

«Maps are more truthful than first-hand experiences»

Topological Map

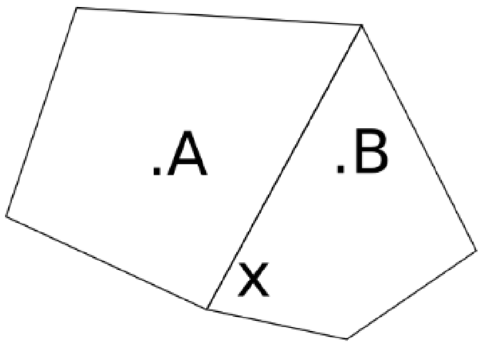


Georeferenced Map

Even experienced travellers interpret schematic maps in a metric way
(Guo, 2011; Raveau et al. 2014)

→ Possible effect: Under-/overestimation of distances

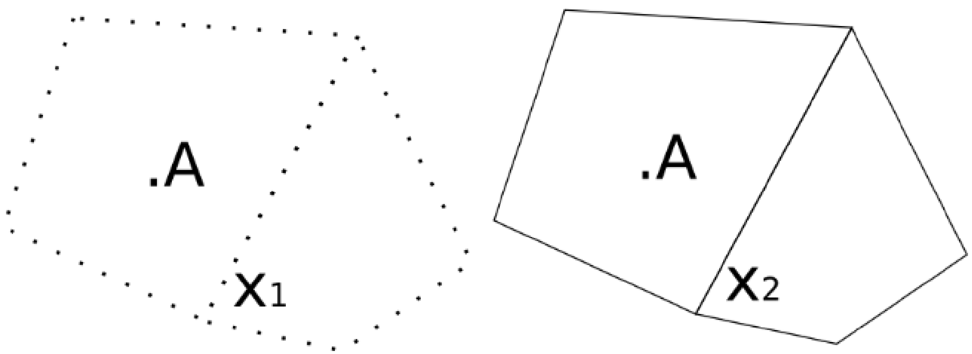
«Political borders are perceived as physical borders»



$EP(x, A) < EP(x, B)$

$dist(x, A) = dist(x, B)$

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



$EP(x_1, A) > EP(x_2, A)$

$dist(x_1, A) = dist(x_2, A)$

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

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

Example	Intended	Unintended
Mercator Map	Greenland is NW of Africa	Greenland is the size of Africa
Tube Map	Stations Victoria and Green Park are connected	dist(Victoria, Green Park) = 3x dist(Green Park, Hyde Park Corner)

Mercator Projection

Tube Map

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$= \{i_{l+1}, i_{l+2}, \ldots, i_n\} \subseteq C$

$\mathrm{C} = \mathrm{I} \cup \mathrm{U}$

- Task-relevant representation = C(R') ⊆ C(R)
- Task-relevant / intended = T_i = $\mathrm{I} \cap C(R')$
- Task-relevant / unintended = T_u = $\mathrm{U} \cap C(R')$

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General Bias

$$\sum_{k=1}^{l} w\left(i'_k\right) > \sum_{k=1}^{m} w\left(i_k\right)$$
$$\text{where } \mathrm{i}' \in U \; and \; \mathrm{i} \in I$$

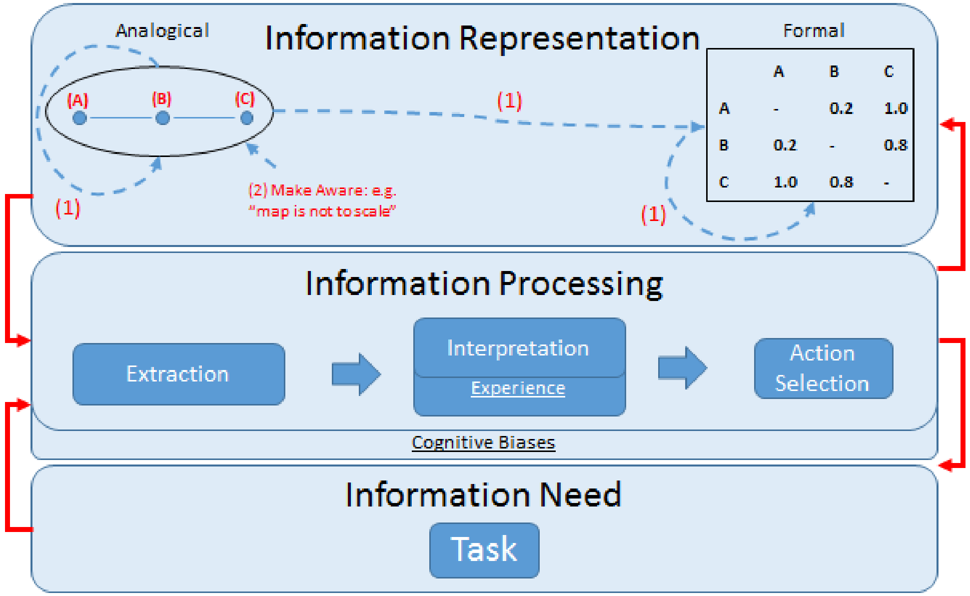
Task-dependent Bias

$$\sum_{k=1}^{l} w\left(j'_k\right) > \sum_{k=1}^{m} w\left(j_k\right)$$

$$where\; j' \in T_u and\; j \in T_i$$

Pragmatic Communication

Task at hand narrows down the relevant information



Tube Map intended for figuring out transport connections

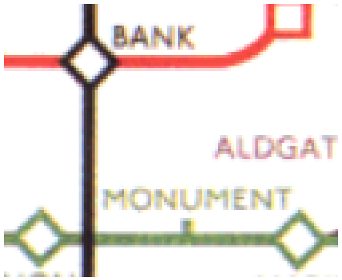
→ Only topology needs to be preserved

Mercator Map intended for (ship) navigation

→ Angles must! be preserved.

Bias Mitigation I: Change in Representation

Bank - Monument



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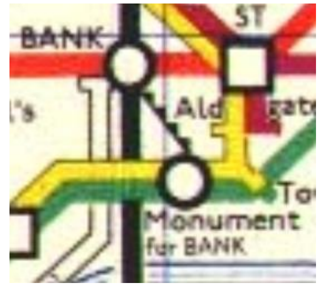

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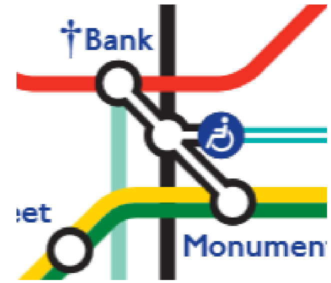
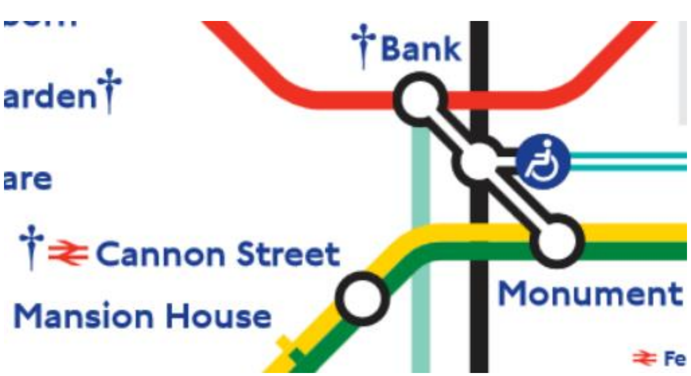
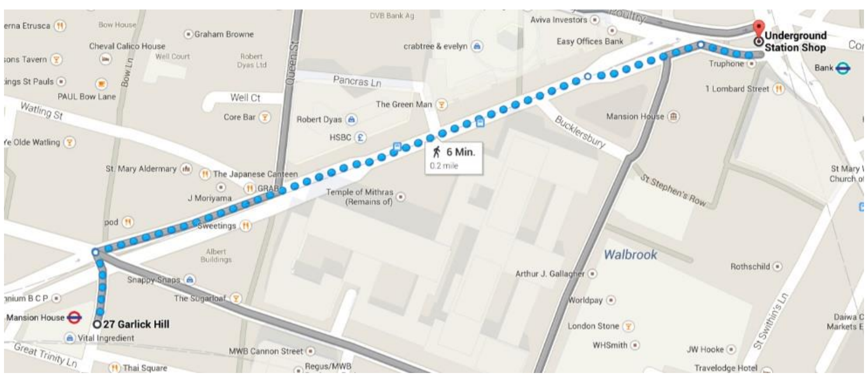


2014

Bank – Cannon Street





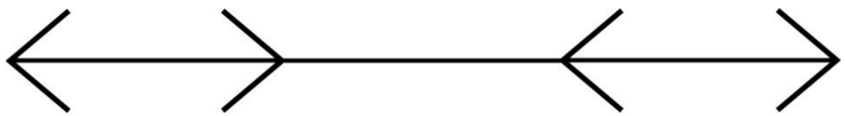
Walk to Monument → Take G/Y Line

Walk to Mansion Street

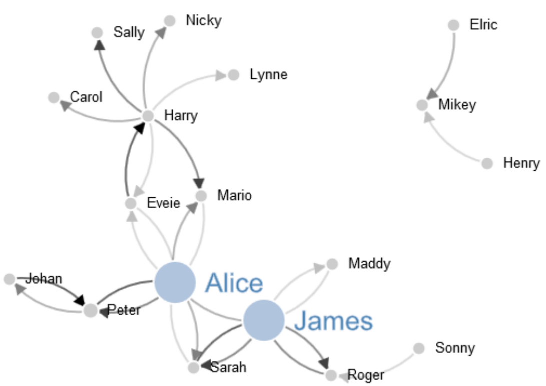
Change in representation can influence the ease of information extraction

Ex: Make length comparison more difficult

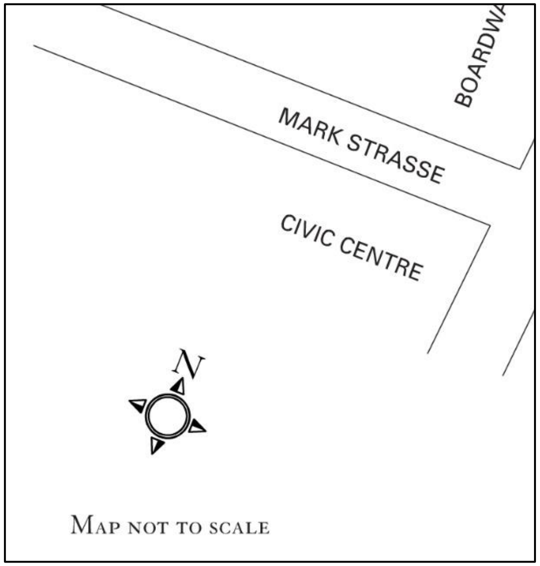
a) Optical Illusion



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

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