Visual Semiotics & Uncertainty Visualization: An Empirical Study

Uncertainty Vis Study group, Fall 2012

Introduction

- Two experiments providing insights on how to signify different categories of uncertainty.
- Efficiency of Discrete symbols in presenting uncertainty of individual items in info graphics.

Introduction

- Three types of uncertainty.
  - Accuracy
  - Precision
  - Trustworthiness
- Matched to
- Three components of information
  - Space
  - Time
  - Attribute.

Conceptualizing Uncertainty

- Overall, 9 types of uncertainty for the three components of information
  - Accuracy/error
  - Precision
  - Completeness
  - Consistency
  - Lineage
  - Currency
  - Credibility
  - Subjectivity
  - interrelatedness

Conceptualizing Uncertainty

Category	Space	Time	Attributes
Accuracy/ error	coordinates., buildings	+/- 1 day	counts, magnitudes
Precision	1 degree	once per day	nearest 1000
Completeness	20% cloud cover	5 samples for 100	75% reporting
Consistency	from / for a place	5 say M; 2 say T	multiple classifiers
Lineage	# of input sources	# of steps	transforma-tions
Currency/ timing	age of maps	C = Tpresent - Tinfo	census data
Credibility	knowledge of place	reliability of model	U.S. analyst vs. informant
Subjectivity	local ←→ outsider	expert ←→ trainee	fact ←→ guess
Interrelatedness	source proximity	time proximity	same author

Conceptualizing Uncertainty

- Most influential is accuracy/error.
- Precision and currency have secondary influence.

Visual Semiotics

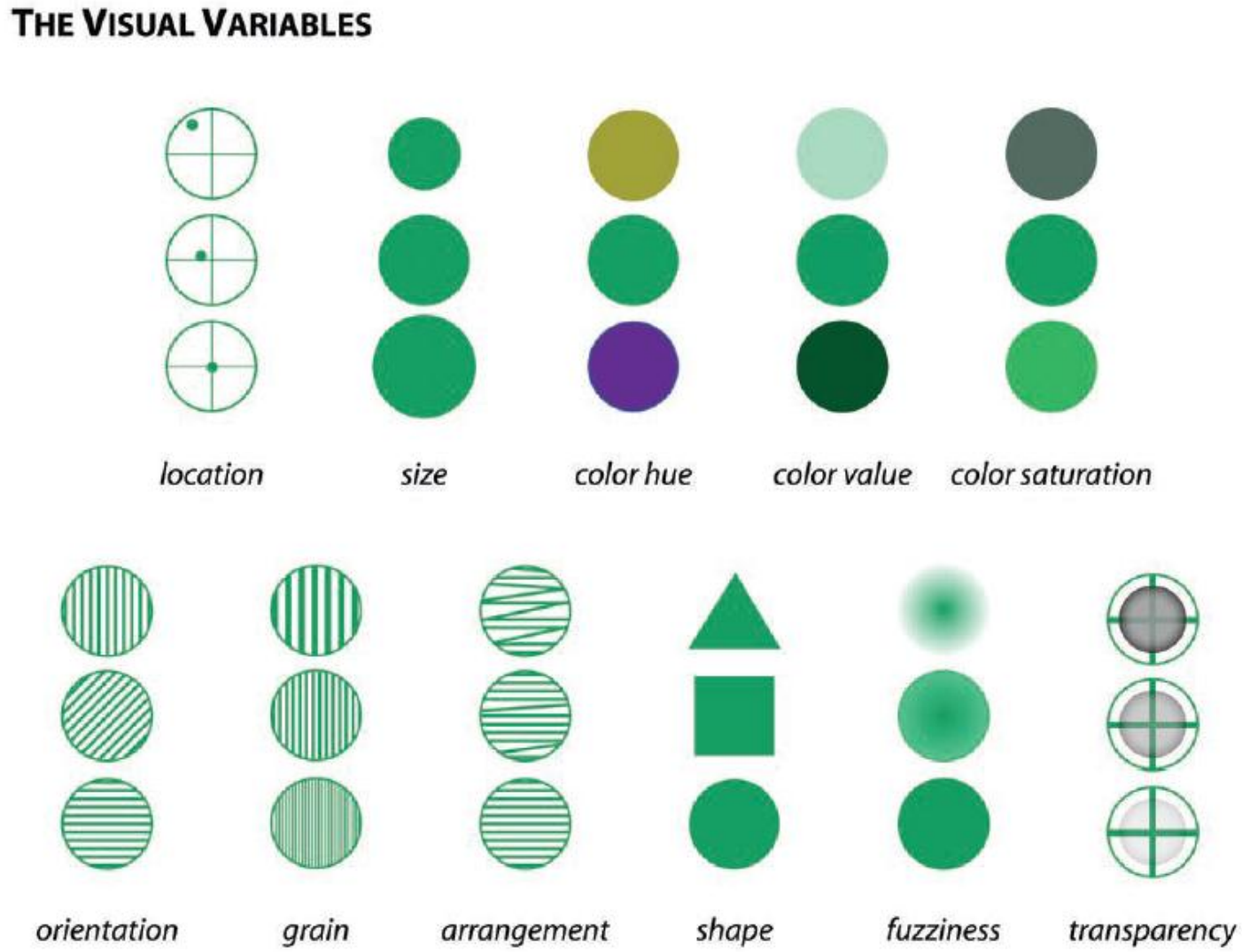


Fig 1. Visual variables applied to point symbol sets.

Experiment #1

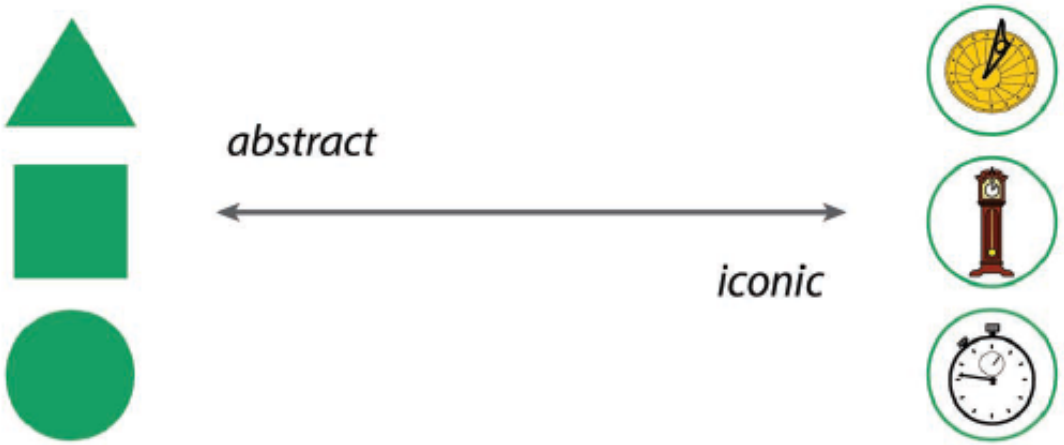


Fig 2. Symbol Iconicity. Abstract symbols (those that are geometric, varying only a single visual variable) are good for tasks that take advantage of pre-attentive processing. However, iconic symbols (those that are associative or pictorial, prompting metaphors) are potentially easier to match correctly with qualitatively different aspects of data, such as uncertainty conditions.

Experiment #1

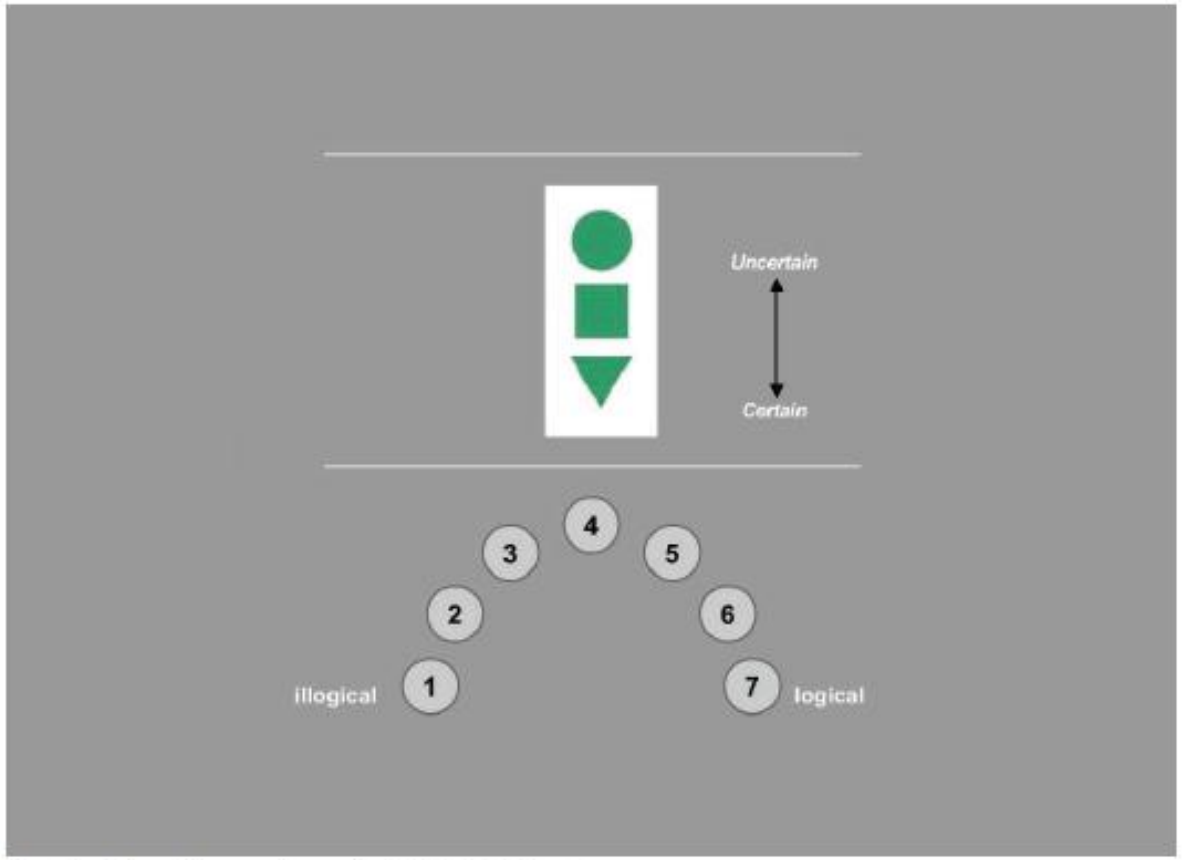
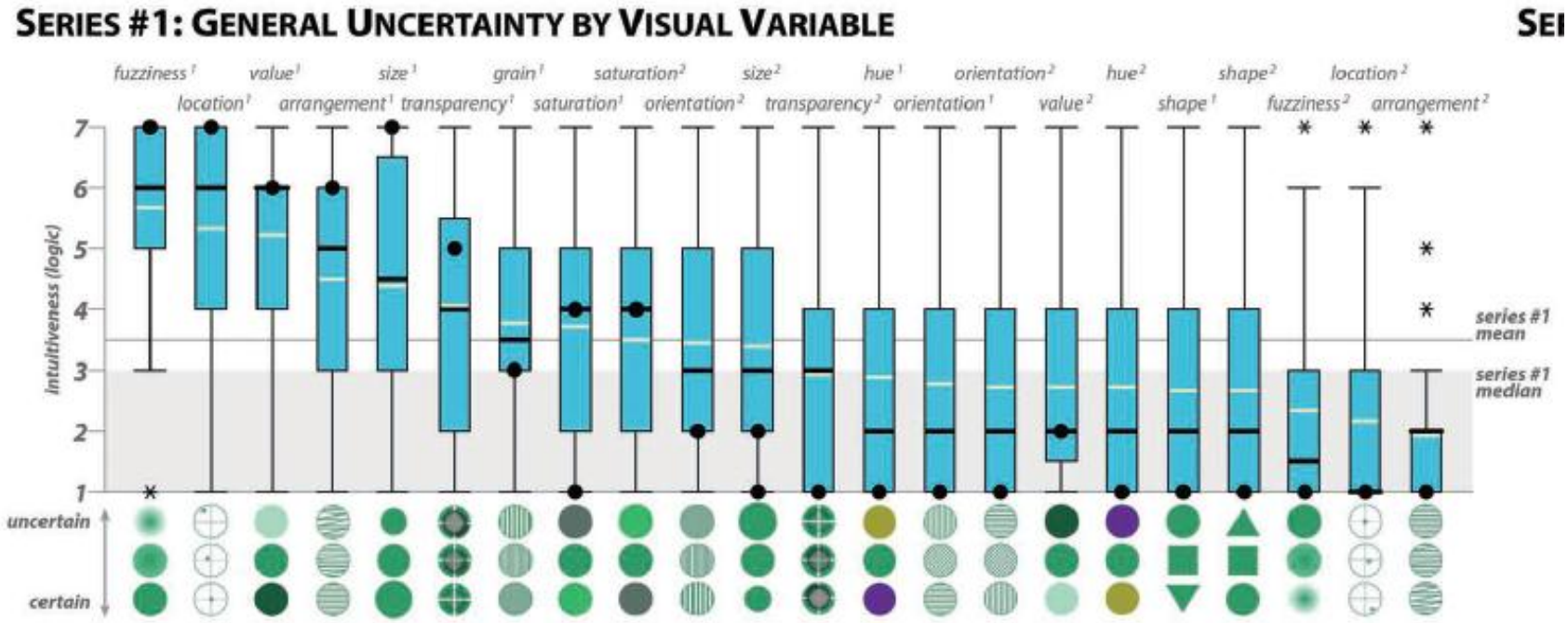
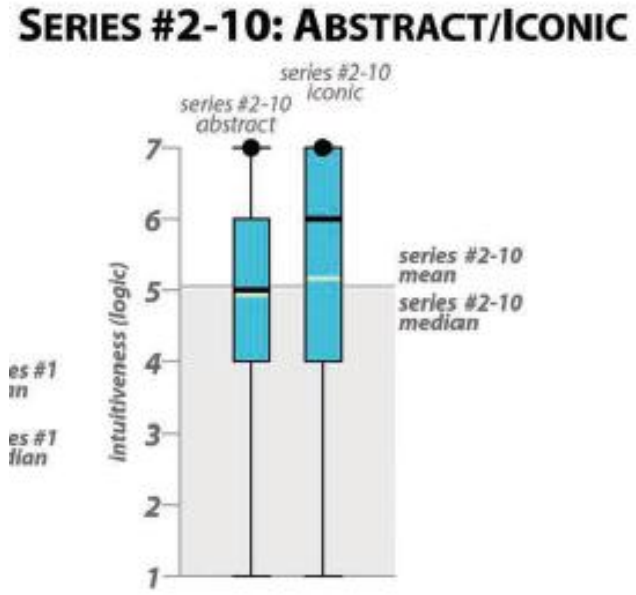


Fig 3. The Experiment #1 trial interface.

Experiment #1



Experiment #1



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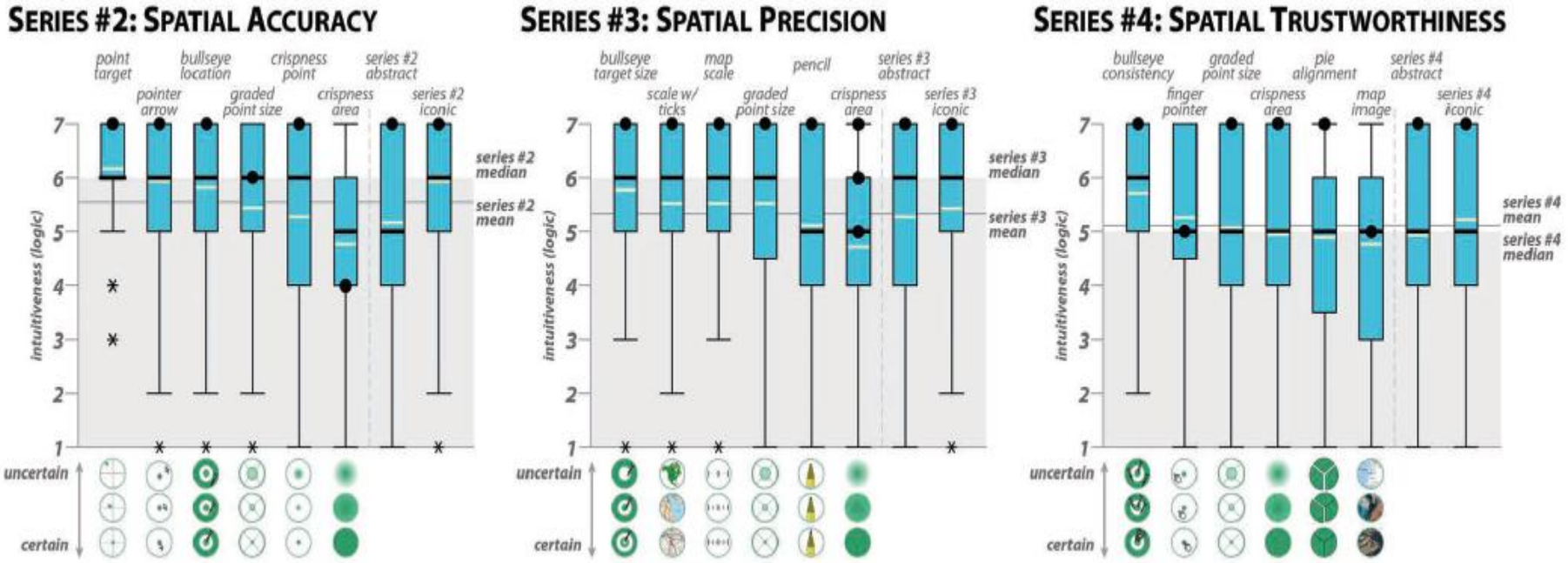

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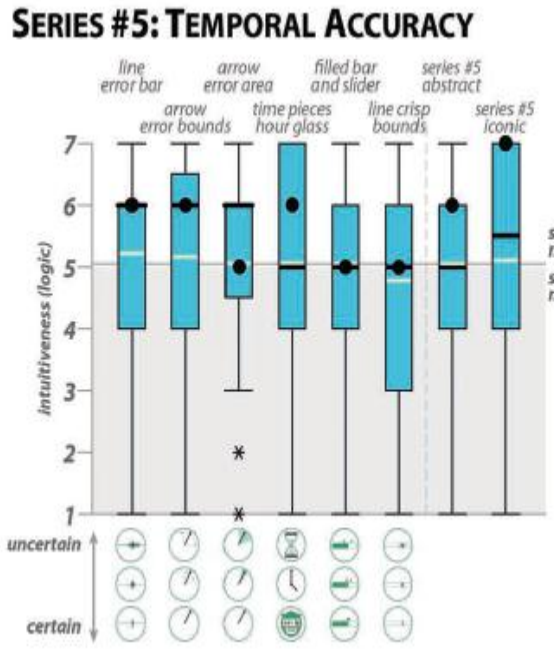

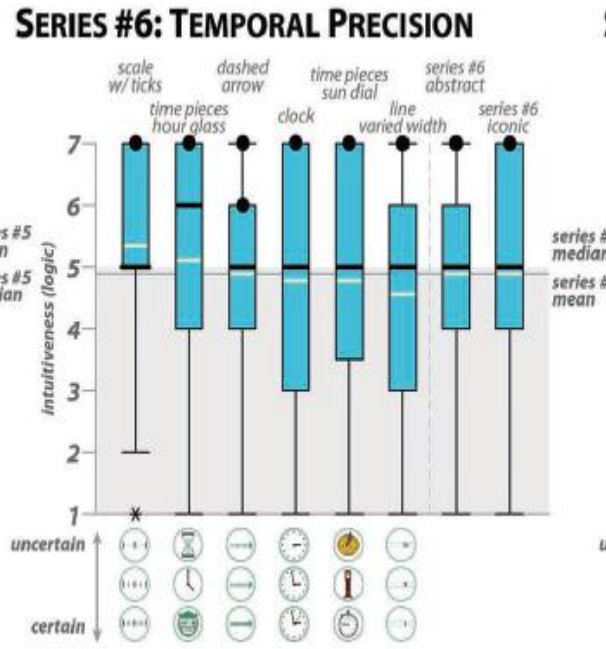

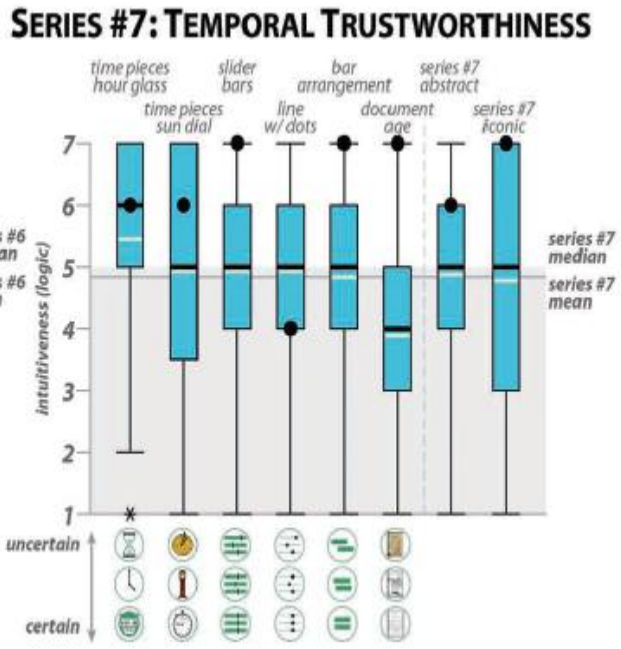

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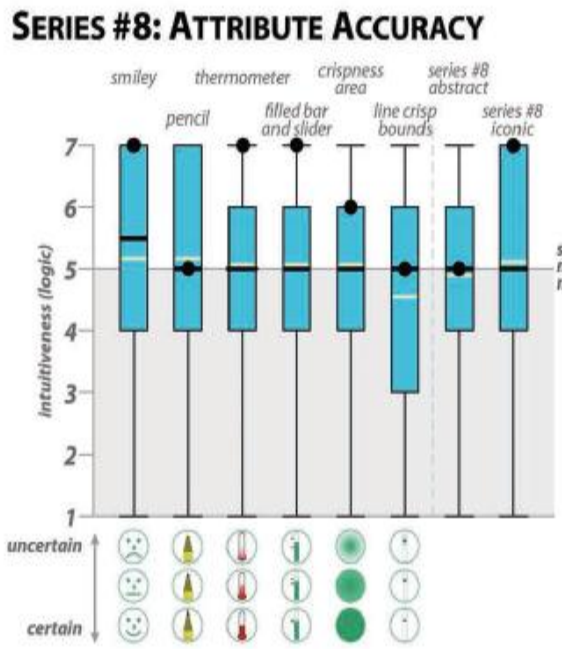

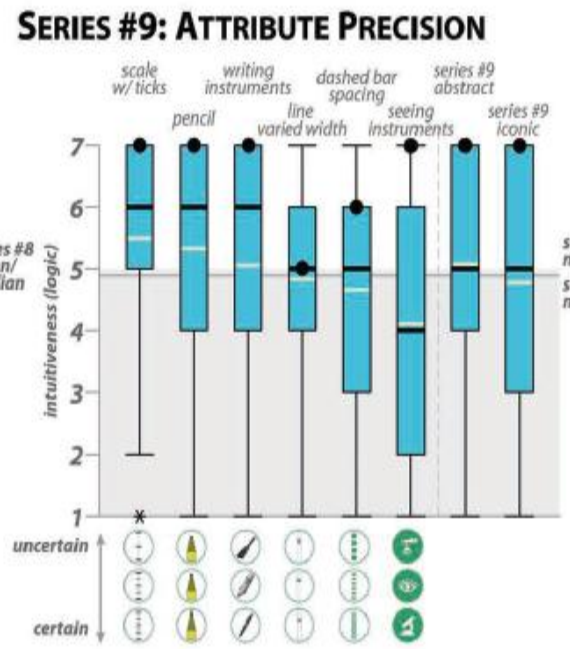

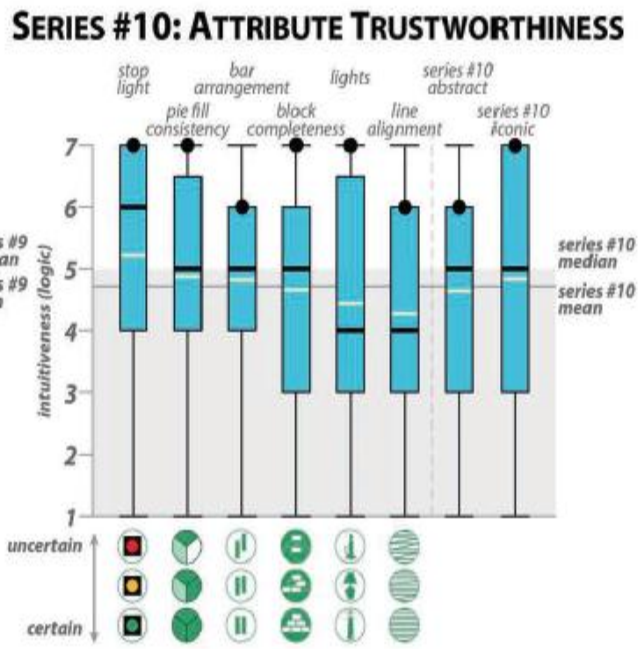

Experiment #1

Series #	Abstract Winner	Iconic Winner
Series #2. Space + Accuracy	graded point size*	point target
Series #3. Space + Precision	scale w/ ticks*	bullseye target size
Series #4. Space + Trustworthiness	crispness area	consistency bullseye*
Series #5. Time + Accuracy	line error bar	arrow error bounds
Series #6. Time + Precision	scale w/ ticks*	time pieces hour glass
Series #7. Time + Trustworthiness	line w/ dots	time pieces sun dial*
Series #8. Attribute + Accuracy	filled bar and slider	smiley
Series #9. Attribute + Precision	scale w/ ticks*	pencil*
Series #10. Attribute + Trustworthiness	pie fill consistency	stop light

Experiment #2

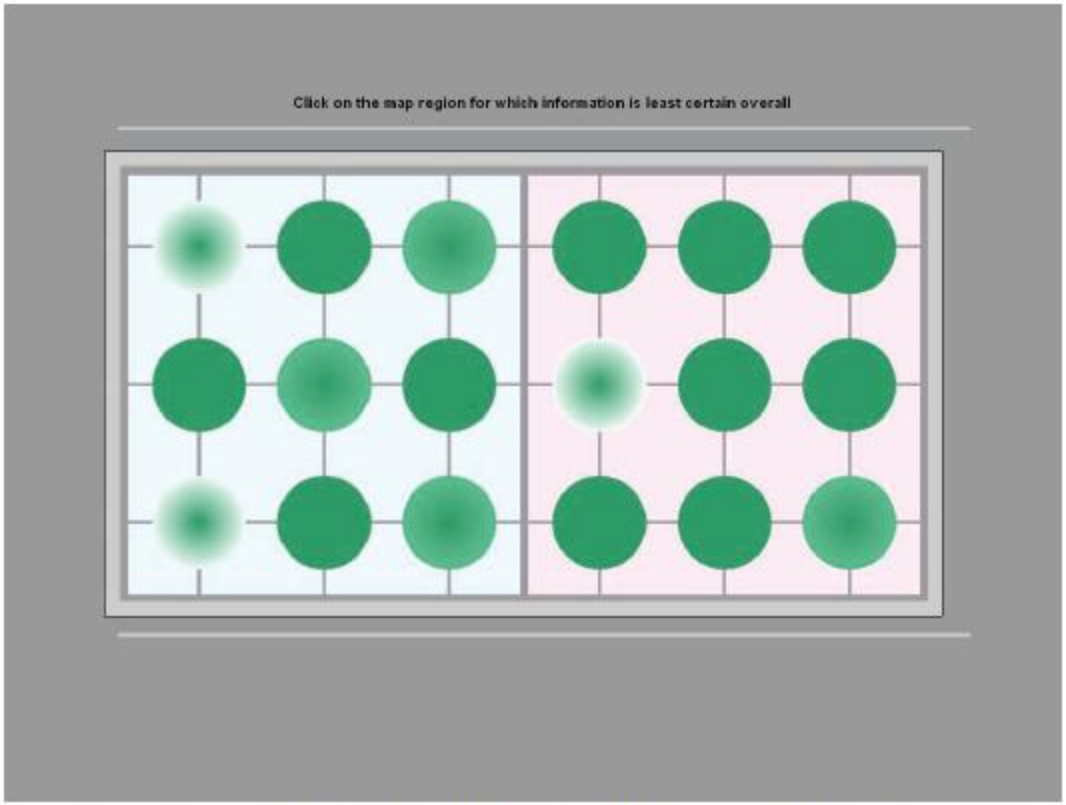

Fig 6. Example screen #2 of an Experiment #2 trial. The trial interface presents two map regions to the participant, each with uncertainty signified for nine locations. The participant must conceptually aggregate the uncertainty of each region and select the region that is least certain by directly clicking on the map.

Experiment #2

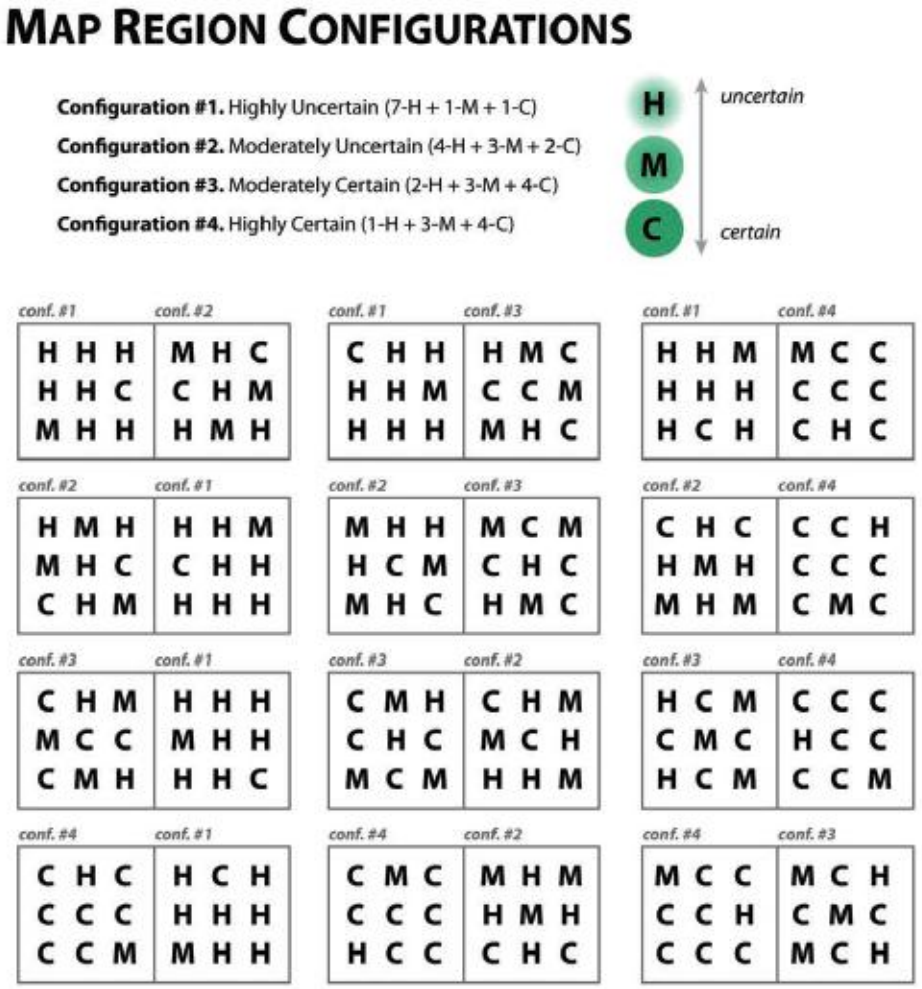

Fig 7. The 12 map region configurations. Each individual map region was allowed to fall into one of four degrees of aggregate uncertainty, producing twelve possible map region configurations.

Experiment #2

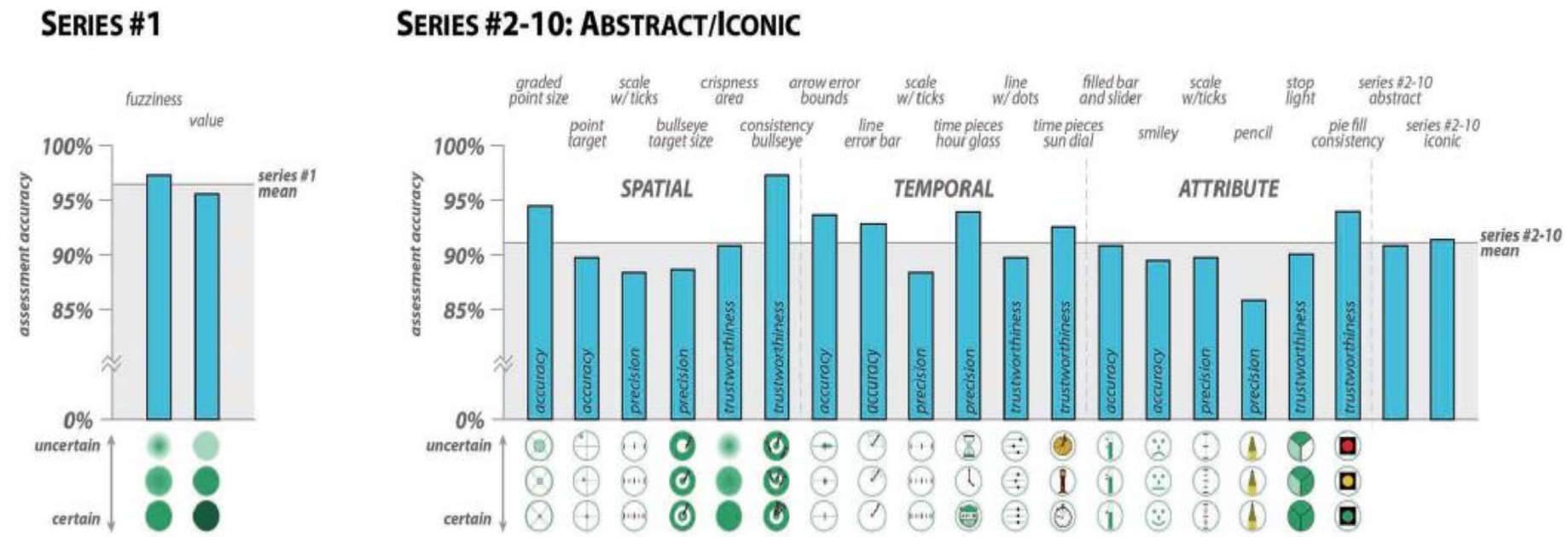

Fig 8. Experiment #2 descriptive statistics by series and symbol set.

Conclusion

- General observation
  - Fuzziness and Location work particularly well.
  - Value and arrangement also rated highly
  - Size and transparency potentially usable.
  - Saturation, often cited as intuitive, ranked quite low.
- Abstract sign vehicles can lead to quicker judgement.
- Generalized to maps, but experiments are generic enough to be applicable to other domains.
- Future Directions/questions
  - What symbolization method works best when data and data uncertainty need to be integrated using the same sign vehicles.
  - Scalable?
  - Background display
  - Experiments here were done on discrete setting, but do the schemes apply to linear or area (field) data?