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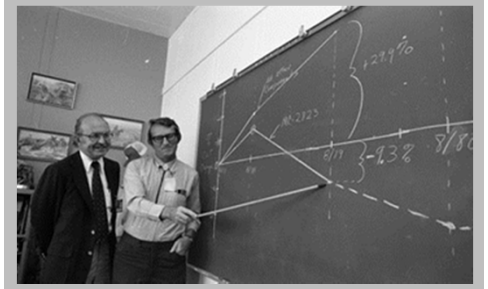

Methodology for Knowledge Elicitation in Visual Abductive Reasoning Tasks

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Sandia National Laboratories

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U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration | CCR Center for Computing Research

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Bias in Knowledge Elicitation

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- Bias: misinterpretation or misrepresentation of expert knowledge or data

Motivational Bias

- Social pressure
  - Group or interviewer
  - Image of self
- Subtleties of language and mental models

Cognitive Bias

- Anchoring
- Inconsistency
- Actual-ideal discrepancies
- Availability
- Estimation of uncertainty

- The potential for bias to affect the results of knowledge elicitation studies is well recognized
  - Attempt to control for bias through careful selection of elicitation and analysis methods

For a thorough discussion of bias, see Booker, M.A.M.J.M., Eliciting and Analyzing Expert Judgment: A Practical Guide, in Eliciting and Analyzing Expert Judgment. 2001, ASA-SIAM. Chapter 3.

Motivation

- New physiological sensors can provide additional dimensions of objective measurements, for example…

Sensor	Cognitive Attributes	Related Bias
 Eye Movements • Head mounted • Screen mounted	• Attention allocation • Workload	• Actual-ideal discrepancies
 Heart Rate • Chest strap • Wrist watch • "All-in-one" biophysical sensor systems	• Physical effort • Cognitive workload • Stress	• Social pressure
 EEG • Portable high fidelity • Gaming and neurofeedback headsets	• Error related negativity • Memory encoding • Drowsiness	• Inconsistency • Availability

Enhanced Knowledge Elicitation Methodology

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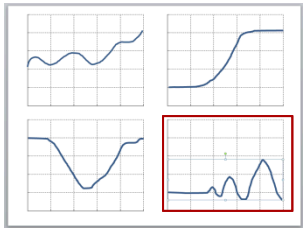
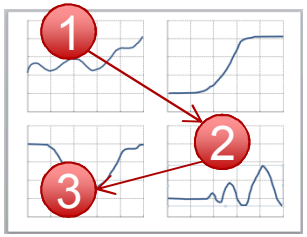
- Incorporate one or more physiological sensors that provide cross referencing information for more traditional knowledge elicitation instruments
- Highlights actual-ideal discrepancies that can be missed during interviews and verbal walkthrough protocols
- Applied to a complex visual abductive reasoning task
  - Engineers who use multivariate time series data to diagnose the performance of devices throughout the production lifecycle

Engineer's Task





Pass/Fail
Cause?

Abductive Reasoning

What?

How?

Why?

Vision

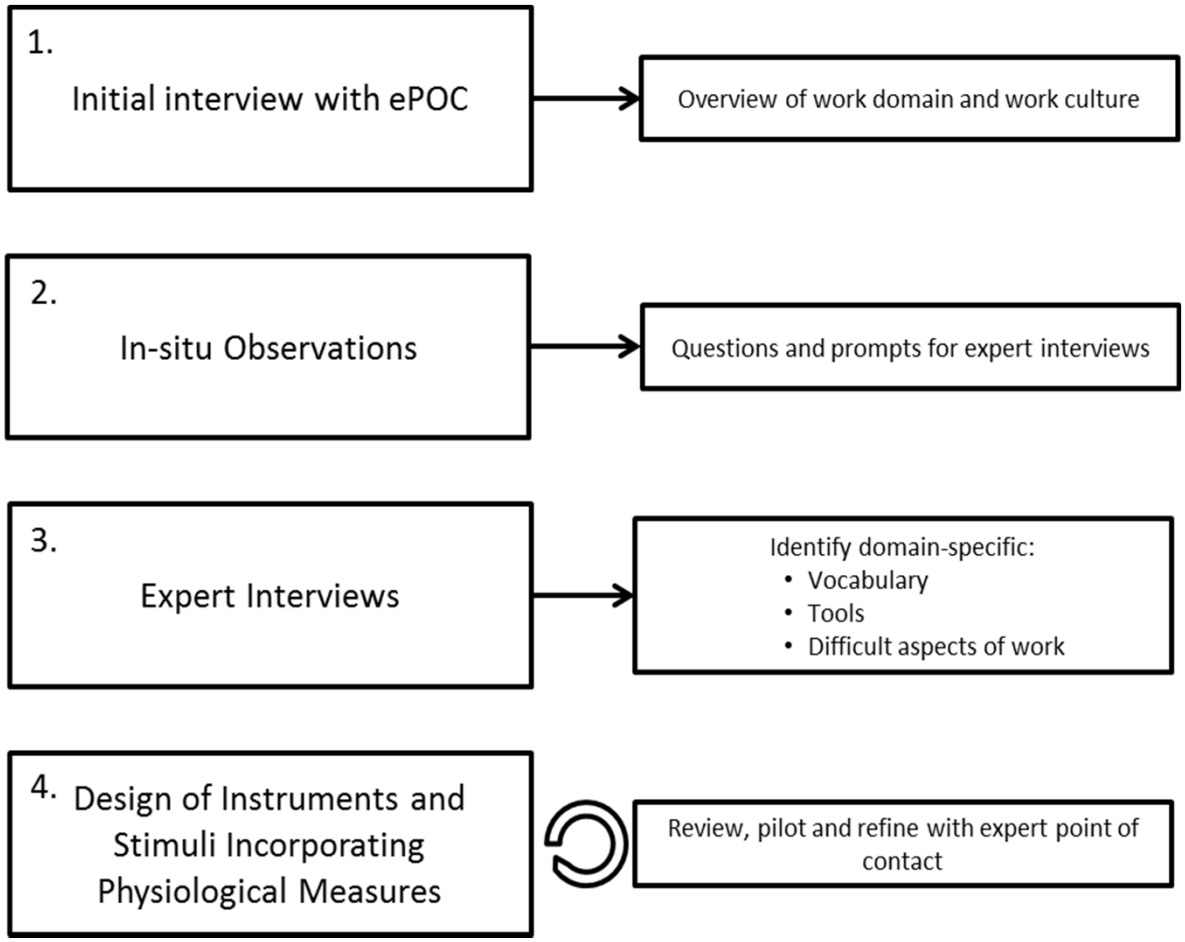
(e.g. by retinal neural activities)

(attentional selection, often by saccading to selected locations)

(e.g. face recognition)

Lower figure paraphrased from Understanding Vision; Theory, Models and Data, Li Zhaoping, Oxford University Press, 2014, Oxford, UK

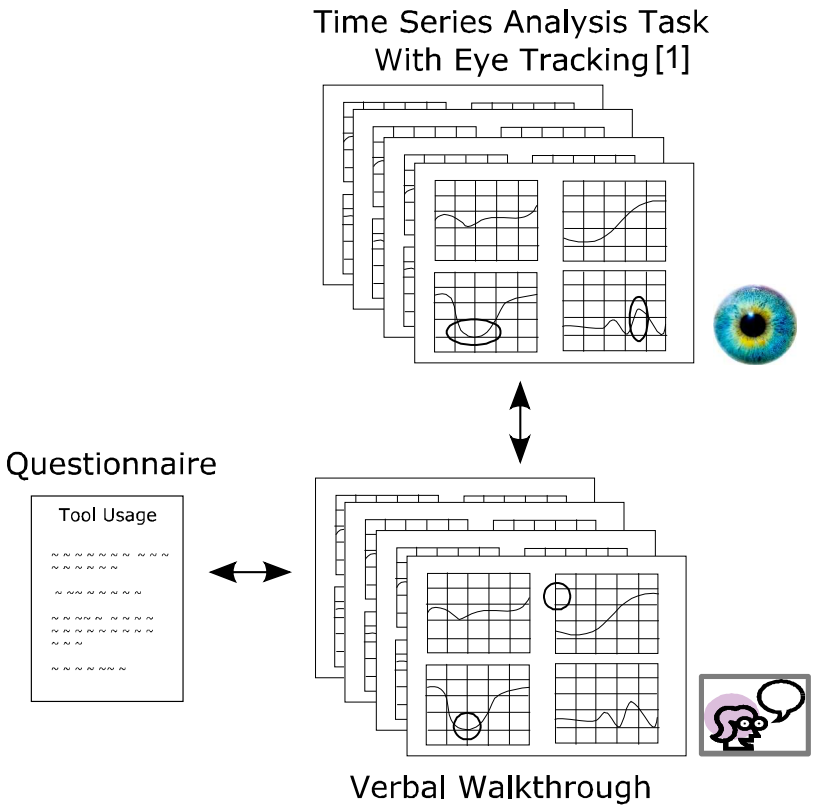
Protocol Design Process



For a thorough discussion of design principles, see Booker, M.A.M.J.M., Eliciting and Analyzing Expert Judgment: A Practical Guide, in Eliciting and Analyzing Expert Judgment. 2001, ASA-SIAM. p. 3-16.

Study Overview

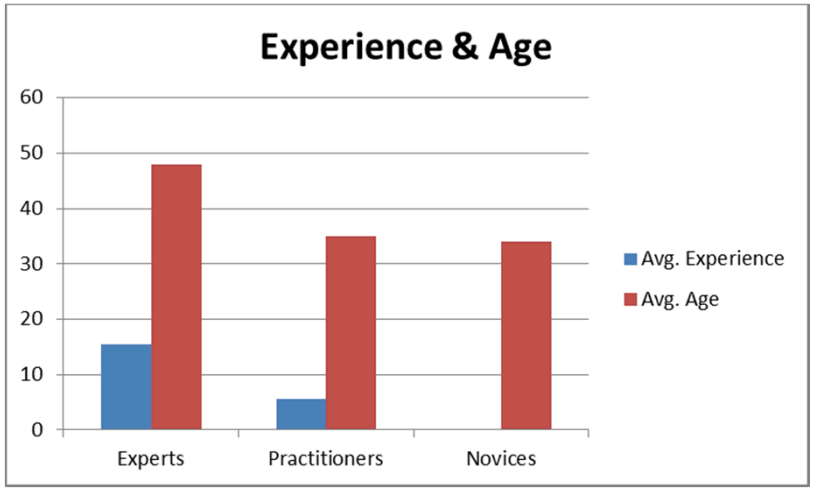
- 13 participants from highly specialized field
  - 3 highly experienced (“experts”)
  - 4 experienced (“practitioners”)
  - 6 without experience (“novices”)
    - For comparative performance baselines
- Multivariate time series task and verbal walkthrough task
  - 15 trials for each subject

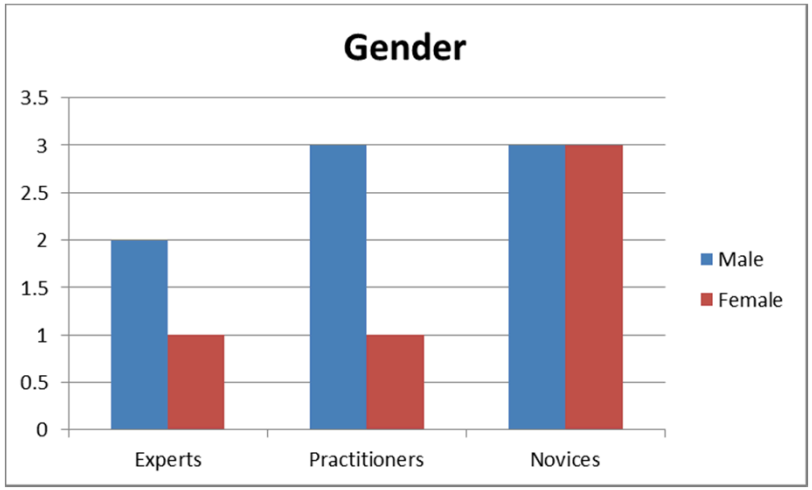


[1] FaceLAB 5 Standard System with two miniature digital cameras and one infrared illumination pod.

Subject Demographics

- All participants earned BA degree or higher
  - All but two earned graduate degrees



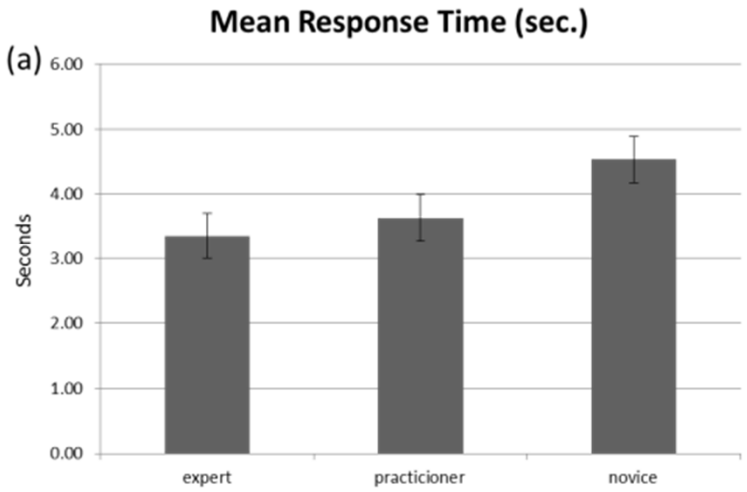


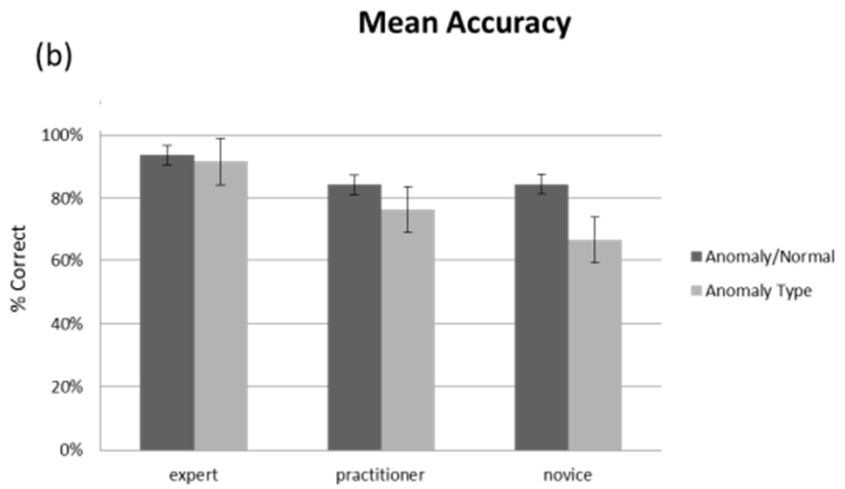
[1] FaceLAB 5 Standard System with two miniature digital cameras and one infrared illumination pod.

Analysis

- Subject response times recorded by custom software written in Java
  - Subject responses for both the anomaly/normal decision and anomaly type were also recorded by this software
- Eye tracking fixation points and durations calculated using EyeWorks Analyze[1] software

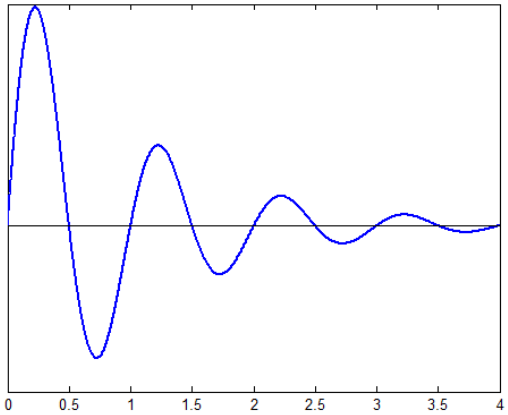
✓ **Experts were faster and more accurate**





[1]EyeTracking Inc., 512 Via de la Valle, suite 200, Solana Beach, CA 92075, USA

Shape Recognition Heuristic



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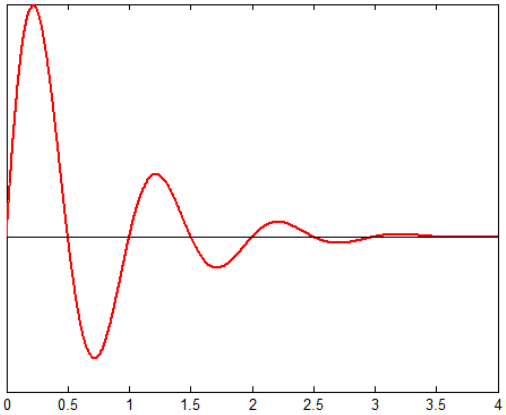
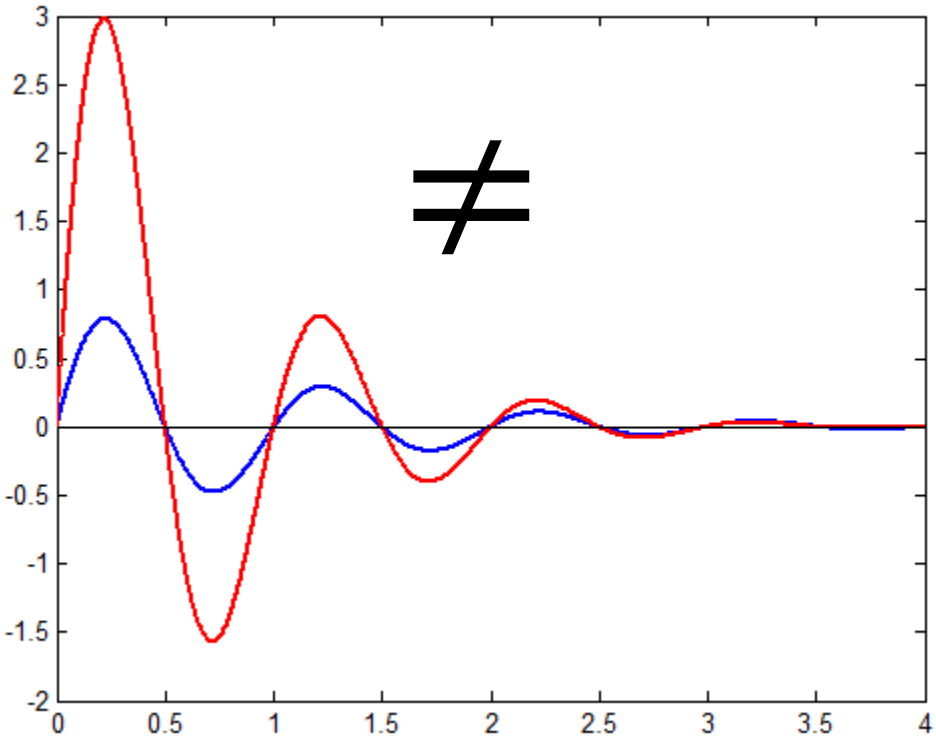
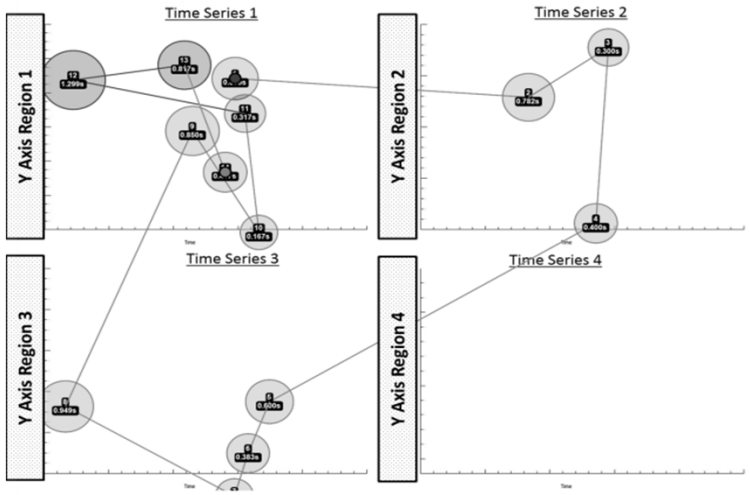


Shape Recognition Heuristic



Results: actual-ideal discrepancies

"Always check y-axis values"



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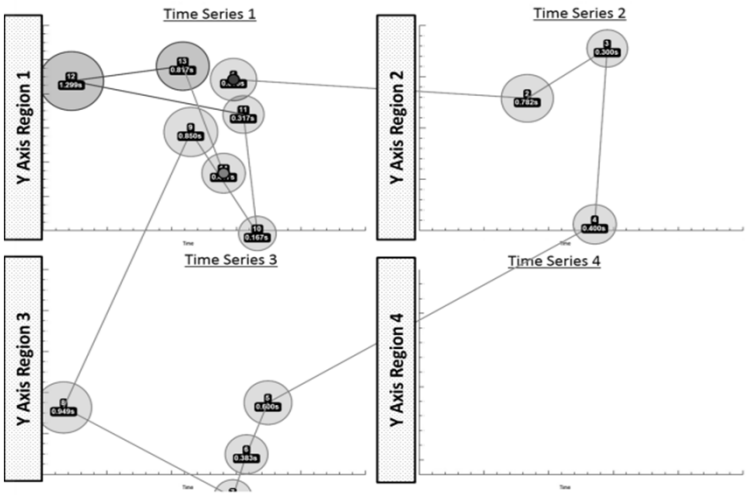

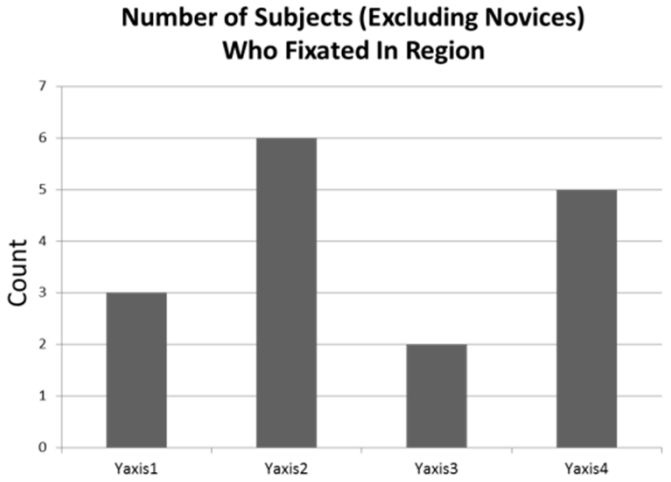

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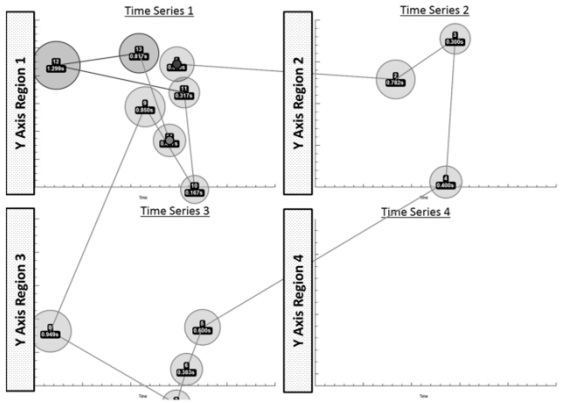
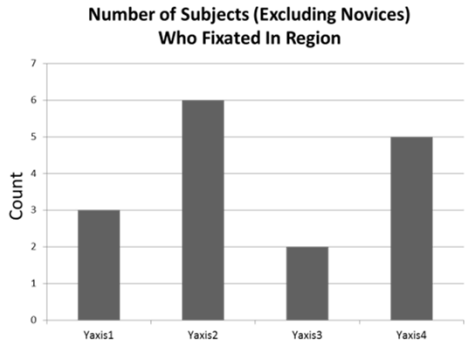
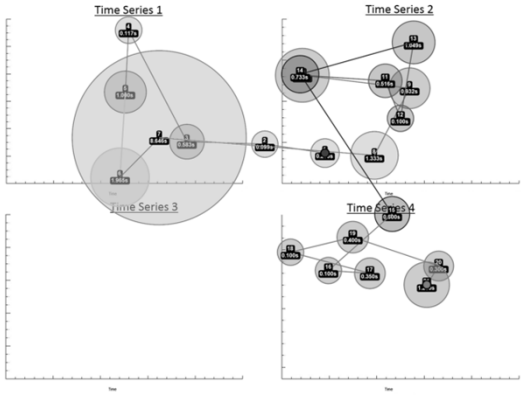




"Always check each data series"



Experts seem to have developed fast shape recognition heuristic

Summary and Conclusion

- Robustness is achieved through incorporation of one or more physiological sensors to provide cross referencing information for more traditional knowledge elicitation instruments.
- Eye tracking is effective at highlighting actual-ideal discrepancies that would not have been discovered by following a traditional verbal walkthrough protocol
- Future work
  - Apply to additional work domains and tasks
  - Develop detailed guidelines for selecting physiological sensors and metrics most appropriate for a given type of task or knowledge elicitation goal

Acknowledgements

- *We wish to acknowledge James D. Morrow of Sandia National Laboratories, Albuquerque New Mexico for creating the software used in our study to display the time series stimuli and record subject response times*