An Eye Tracking Study on Expert/Novice Differences During Climate Graph Reading Tasks: Implications for Climate Communication

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Introduction

The communication of climate change information is often a difficult task due to the interdisciplinary nature of the topic in addition to the challenges of communicating these topics with their intended audiences. In order to present this information effectively, it is important to understand how novices (e.g., the general public) navigate this data differently than experts. In this study, students viewed graphs displaying climate change information and their gaze patterns were collected. Gaze patterns of scientific experts (geoscience graduate students) were used as a comparison to the novices (undergraduate students).

Research Questions:

1. How do expert and novice eye movements differ?
2. How does the amount of time experts and novices spend viewing graphs differ?
3. To what extent do expert and novice interpretations differ?

Methods & Tools

Eye-Tracking : *What is it? Why use it?*

- *Non-invasive* – collects data without interfering with participants' normal viewing patterns
- Collects data on *attention* (where and when one looks and for how long)

From eye-tracking data, we can:

- Create **heat maps** – show where participant looks and for how long
- Create **gaze plots** – show where and when participant looks
- **Statistically analyze** when, where and for how long a participant focused attention on any *area of interest* (AOI) defined by the researcher

Tools and Materials Used:

- Eye-tracker – Tobii TX300
- Graph pre-assessment - to determine prior knowledge about graph reading, interpretation and construction

Study Design

Study Design

- Participants take pre-assessment
- Eye-tracking study – view graphs and answer questions
- View four different graphs with six questions per graph

Questions

Q1: What is the main idea of this graph?
Q2: What trends do you see in this graph?
Q's 3a & b: Visual lookup of answer (e.g. What was the approximate Sea Level change in 1950?)
Q's 4a & b: Extrapolation or application of prior knowledge (e.g. What might global temperature be in 2050?)

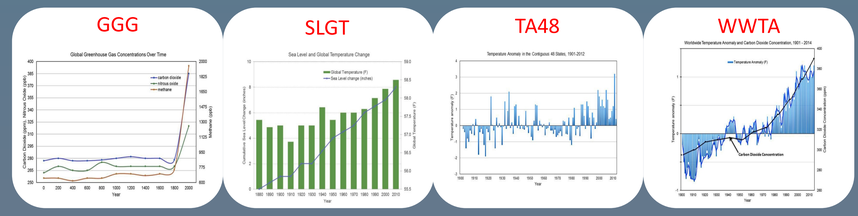
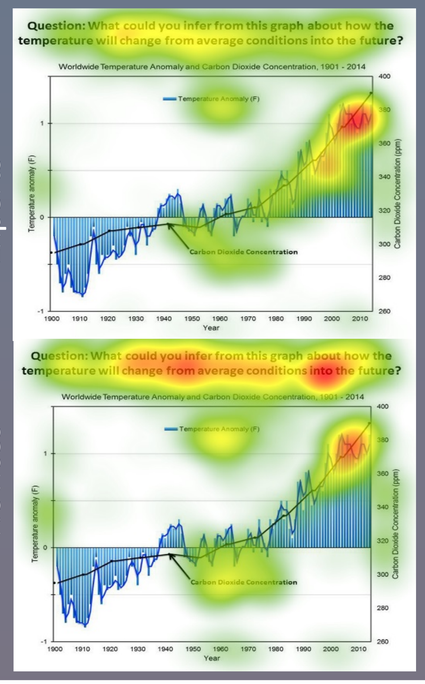


Figure 1. Graphs used for this study. All graphs contain climate content and were modified from their original EPA (EPA, 2016) publication format for consistency in color, line thickness and overall readability.

Results



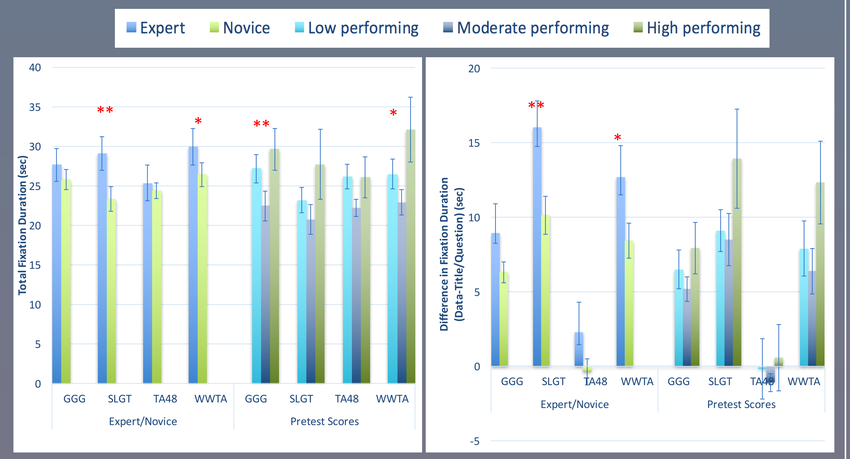
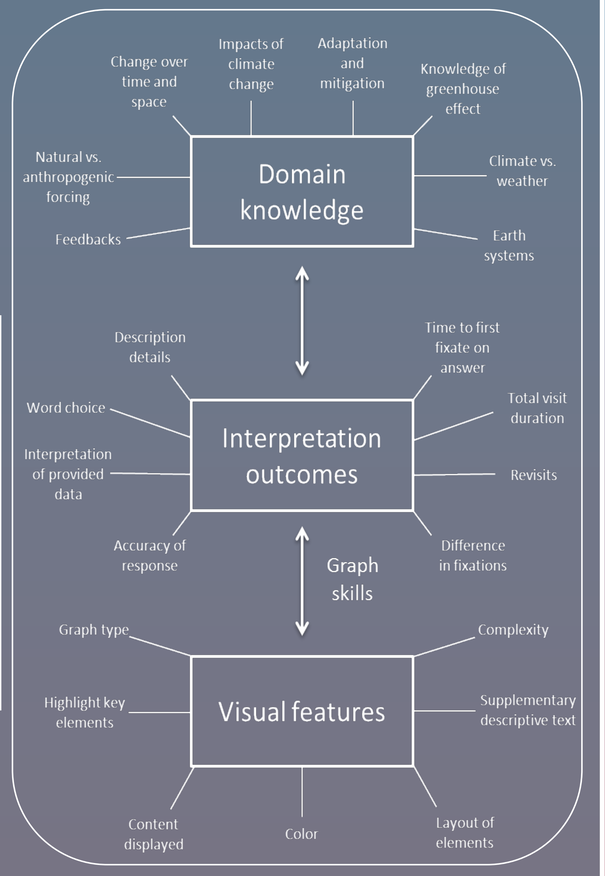


Figure 2 (left). Fixation duration heat maps showing differences between data fixation durations and question/title fixation durations for experts (top) and novices (bottom). Red indicates locations where more attention is allocated. Relative duration calculation, radius = 205px, opacity = 75%.

Figure 3 (above). Summary statistics of total fixation durations and differences in fixation durations displayed based on the type of question being asked or the type of graph being displayed. ** indicates p<0.05 * indicates p<0.1

Figure 4 (below). Construction Integration (CI) model for graph construction and interpretation (Freedman and Shah, 2002) modified for climate content and measured metrics.



Conclusions

1. How do expert and novice eye movements differ?

- Experts = focus more attention on task-relevant information (i.e. data trends, axes, legend, etc.)
- Novices = focus more attention on task-irrelevant information (title, question)
- High-performing novices (top 1/3 of pretest scores) behaved more expert-like

2. How does the amount of time experts and novices spend viewing graphs differ?

- Experts = spend more time answering main idea and bringing in prior knowledge/extrapolating (Q4)

3. To what extent do expert and novice interpretations differ?

- Expert responses = longer, more in-depth explanations, include prior knowledge
- Novices = describe general trends

Our Recommendations for instructors:

1. Provide opportunities for students to increase their knowledge of graph reading and climate content (Freedman and Shah, 2002).
2. Offer scaffolding and training aimed to help students direct attention to data elements (i.e. axes, legends, data trends, etc.) (Wang et al., 2012).
3. Implement changes to graphs that simplify empirical data (Spence and Lewandowsky, 1990) and/or direct viewer attention to data elements either through visual emphasis (i.e. arrows, highlighting, etc.) or adjoining text.

References

Environmental Protection Agency (EPA). 2016. Climate change science. Available at www3.epa.gov/climatechange/science/ (accessed 19 February 2016).

Freedman, E.G. and Shah, P. 2002. Toward a model of knowledge-based graph comprehension. Diagrammatic Representation and Inference, 2317:18-30.

Spence, I. and Lewandowsky, S. 1990. Graphical perception. In J. Fox & J. S. Long, eds., Modern methods of data analysis, p. 13-57.

Wang, Z.H., Wei, S., Ding, W., Chen, X., Wang, X. and Hu, K. 2012. Students' cognitive reasoning of graphs: Characteristics and progression. International Journal of Science Education, 34:2015-2041.