Multimodal Dynamics of Explaining the Mechanisms of Global Warming

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How do language and gaze patterns reflect the processes behind learning about and teaching others about global warming?

INTRODUCTION

- Despite overwhelming scientific consensus, many Americans do not believe that climate change is occurring, and even fewer believe that human activity is a major cause of it [3].
- Learning about the scientific processes of global warming can lead to opinion change [2].
- As one of the most important problems of our time, it is vital that we find ways to improve non-scientists' understanding of its mechanisms.
- The current study adds to the growing research on "**climate change cognition**" by exploring the **multimodal signatures of learning about and then explaining global warming**. We do so by combining established methods in cognitive science:
  - **Eye tracking** can reflect underlying cognitive processes [5], including effortful attention [6]
  - **Latent semantic analysis** can analyze text and speech to quantify a person's conceptual grasp of a topic [1]

METHOD

- **Participants**
  - 25 undergraduate students from UC Merced participated in return for course credit
  - Subject pool demographics: 18 - 55 years old (M = 19.59 years); 68.33% female, 31.25% male, 7% decline to answer
- **Method**
  - After informed consent, self-reported their confidence in their beliefs about climate change
  - Eye-tracked using an SMI red-m remote eye tracker during the **two-phase experiment**:
    - **"Watch"** phase: Watched 5-minute apolitical video explaining the scientific mechanisms of climate change [4]
    - **"Explanation"** phase: After 30-second waiting period, participants were asked to explain the mechanisms aloud (in less than 2 minutes) so that a future participant could learn the information
- **Data analysis**
  - **Attention** measured as pupil diameter of right eye (in pixels), sampled at 10Hz, with larger pupil diameter indicating higher increased attention [6]
  - **Fluctuations in attention** measured as the first derivative of right pupil diameter
  - **Comprehension** measured as the conceptual similarity of the participant's explanation to the original stimulus
    - Performed latent semantic analysis (LSA) between each participant's transcribed explanation and the video transcript within the TASA space [1]
  - Used **growth curve modeling** to explore how the different dynamics of attention over time by creating first- (i.e., linear) and second-order (quadratic) time polynomials [5]
  - Centered and standardized all variables, allowing us to interpret model estimates as **effect sizes** [7]

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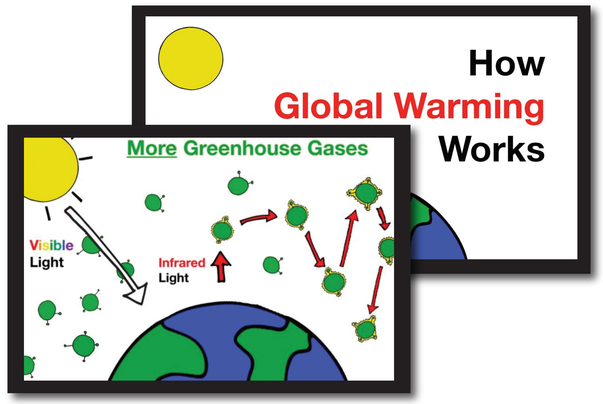

Figure 1: Screenshots taken from the video – "How Global Warming Works (in Under Five Minutes)" [4] – shown to partiicpants during the "watch" phase.

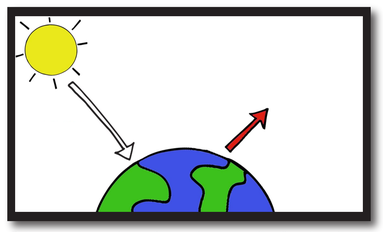

Figure 2: Image shown to participants during the "explanation" phase.

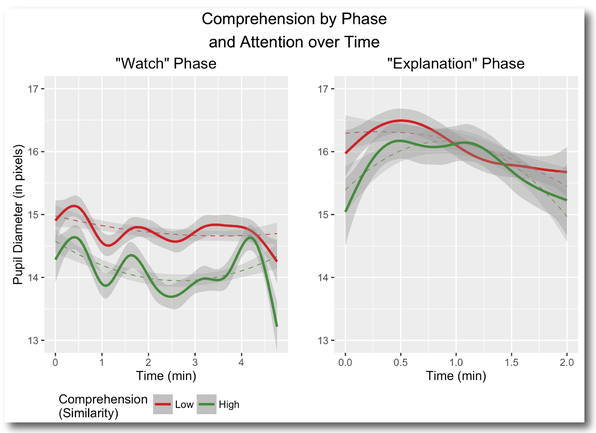

Figure 3: Plotting of the three-way interaction effects for phase ("watch" and "explanation"), attention (pupil diameter in pixels), and time on comprehension (LSA-determined similarity between explanation and stimulus). The best-fit quadratic is overlaid in the thin dotted lines of the corresponding color in each panel.

RESULTS

- Created two **linear mixed-effects models** [8] using self-reported confidence in climate change knowledge as the sole random intercept
- **Model 1**: Predicted comprehension with attention**,** phase (watch/explain)**,** linear time, quadratic time, all two-way interactions, and three-way interactions for time (linear and quadratic, separately) ***x*** phase ***x*** attention
  - **Small-to-moderate effect sizes** ($|\beta|$s>.15, *p*s<.0001) **for 6 variables**: phase (+), linear time ***x*** phase (+), quadratic time ***x*** phase (+), phase ***x*** attention (-), linear time ***x*** phase ***x*** attention (-), and quadratic lag ***x*** phase ***x*** attention (-) [see Fig. 3]
  - All other variables *n.s.*
- **Model 2**: Identical to model 1, but substituting fluctuations in pupil size instead of raw pupil size
  - All variables *n.s.*

DISCUSSION

- Although preliminary, our results suggest that there are some key differences in the behavioral signatures of learning versus teaching others about climate change mechanisms, even when accounting for existing personal beliefs.
- **Watching the video** was characterized by a stronger **linear decline in attention** over time, while **explaining** these concepts was associated with a **negative quadratic pattern of attention**.
- **Higher conceptual comprehension** appears to be associated with a **sharper quadratic profile with a later peak** of attention while explaining (see Fig. 3).
  - Overall, participants might be investing effort in planning their explanation early, allowing them to conserve resources as they wind down their explanation.
  - High-performers, however, appear to spend more time in this investment period, while low-performers may provide only a quick burst of effort before beginning to disengage.
- Unfortunately, within the current sample, we were unable to recruit any participants who reported doubting climate change. Future work should examine whether these patterns of attention and conceptual comprehension hold for those who doubt climate change.

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