

Lecture will start at 9:35

Assignments reminder

Keep doing your PMIRO+Q

Would be nice if you did the mid-term course evaluation (sent announcement)

Your third coding assignment is due **Friday, March 20th** by 8am.

Your project description will be due **April 1st by 11:59pm**

Climate Change in the News

Trump officials fire 800 employees at weather forecasting and oceans agency

By [Ella Nilsen](#) and [Tami Luhby](#), CNN

🕒 3 minute read · Updated 10:08 AM EST, Fri February 28, 2025



The terminations are a blow to an agency that has been understaffed for years, even as the climate crisis accelerates and extreme weather becomes more frequent. Critics of the administration’s plan to slash the agency — a directive that was outlined in Project 2025 — have said layoffs would further cripple America’s ability to accurately forecast hurricanes, tornadoes and other costly, deadly extreme weather.

Meteorologists and computer engineers across NOAA were impacted, including at the Hurricane Research Division, where employees work to increase the accuracy of hurricane forecasts. Andrew Hazelton, a researcher with a PhD in meteorology, was one of the employees terminated Thursday, he said on social media. His role was to evaluate hurricane forecasts and improve the physics in the models that the National hurricane Center uses to track the storms.

“I enjoy meteorology because weather affects everyone, and there’s always so much to learn,” Hazelton is quoted as saying in his NOAA bio. “Growing up in Florida, I experienced several hurricanes, and it thrills me to be able to study and analyze them in my career.”

Other departments in which roles were terminated include the Pacific Tsunami Warning Center, the Great Lakes Environmental Research Laboratory, and the division that develops and improves the United States’ weather models.

Zachary Labe was one such modeler that was terminated.

“My job was to strengthen NOAA’s use of machine learning and AI for subseasonal-to-decadal weather and climate prediction,” Labe said on X.

Climate Change in the News

Farmers depend on climate data. They're suing the USDA for deleting it.

Growing food is a precarious business, and losing access to key information makes it worse.



Alejandra Villa Loarca / Newsday RM via Getty Images

“Farmers are on the front lines of climate change,” said Jeff Stein, an associate attorney with the environmental nonprofit Earthjustice, who is representing the plaintiffs. “Purging climate change web pages doesn’t make climate change go away. It just makes it harder for farmers to adapt.”

“All of a sudden, it’s like anything marked with climate is starting to disappear,” said Wes Gillingham, the board president of NOFA-NY. According to the complaint, the Farm Service Agency and Farmers.gov, both part of the USDA, removed information about how farmers could access federal loans and technical assistance to start adopting practices that help reduce emissions and sequester carbon, known as climate-smart agriculture.

One tool that allowed farmers to assess their risk level when it came to climate impacts was an interactive map published by the U.S. Forest Service, which combined over 140 different datasets and made them accessible to the general public, said Stein. Land managers could see how climate change is expected to impact natural resources throughout the country; for example, they could look up which watersheds are projected to face the greatest climate impacts and highest demand in the future. But this tool is no longer available. (At the time of writing, a [link to information about the map](#) on the Forest Service’s website turned up dead.)

Lecture

Climate Change: Human beliefs and how to change them

Machine Learning: Natural Language Processing, Transformer, Topic Clustering

Project Homework

Everything is done by people



N.Y.U. Chooses Linda Mills as Its Next President

Dr. Mills will become the first woman to head New York University, one of the largest private universities in the country.



Stephen John Brademas Jr. (March 2, 1927 – July 11, 2016). NYU President from 1981 to 1992



Eric Adams, Mayor of New York City since 2022

Everything is done by people



N.Y.U. Chooses L. Mills as President

Dr. Mills will become the first woman to lead the University, one of the largest in the world.

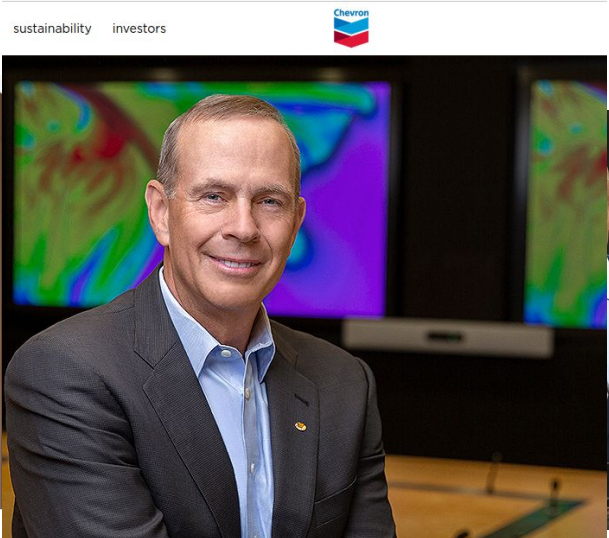


Executive Committee

The Shell plc Executive Committee, led by CEO Wael Sawan, is responsible for running Shell's businesses and delivering on its corporate strategy.

[Read more](#) →

L. Mills (March 2, 1927 – July 11, 2016). NYU President from 1981 to 1992



mike wirth

chairman of the board and chief executive officer



f New York

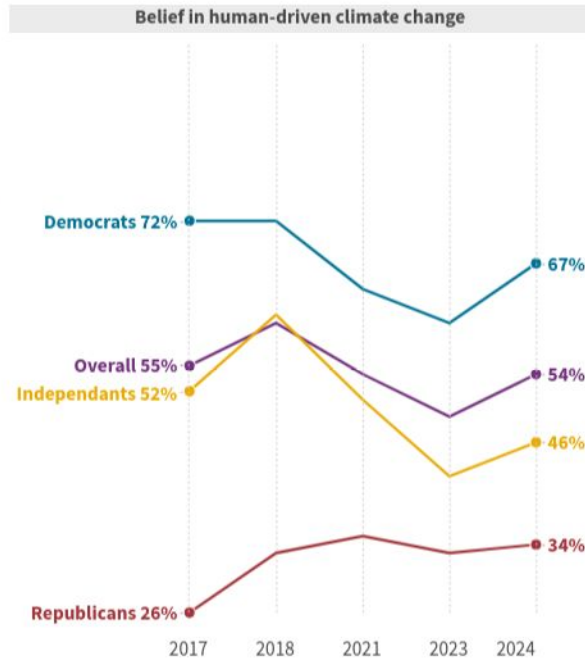
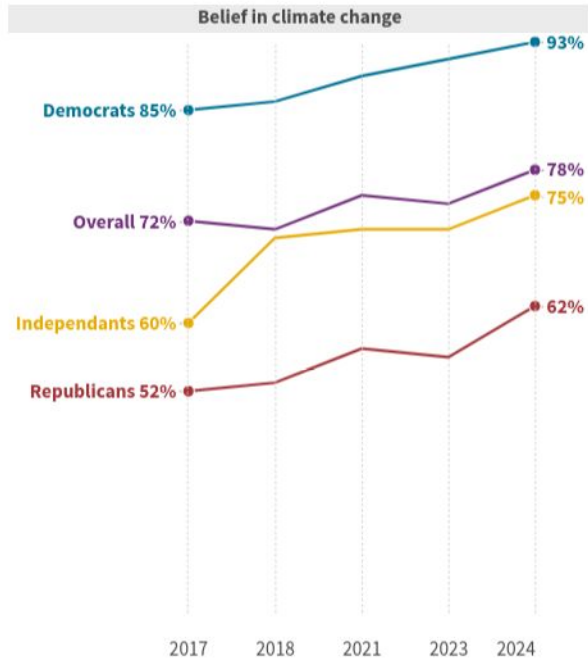
Everything is done by people



Not just as individuals, but also collectively

What do people think about climate change?

Climate attitudes over the years

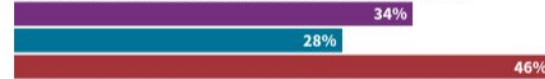


Source: EPIC-AP/NORC Public Opinion Poll • Note: "Belief in human-driven climate change" refers to respondents saying they believe climate change is caused entirely or mostly by human activities. Due to a small sample size, the difference between the beliefs of young and old Republicans could only be reported in certain years where there was statistical significance.

What do people think about climate change?

Support for climate and energy issues

Protect and expand U.S. fossil fuel development



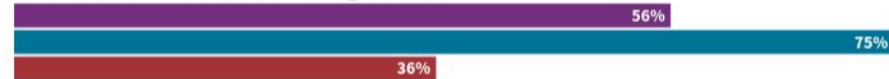
Reduce U.S. greenhouse gas emissions



Expand the U.S. clean energy industry



Enforce strict clean air and water regulations



Protect conservation lands and wildlife

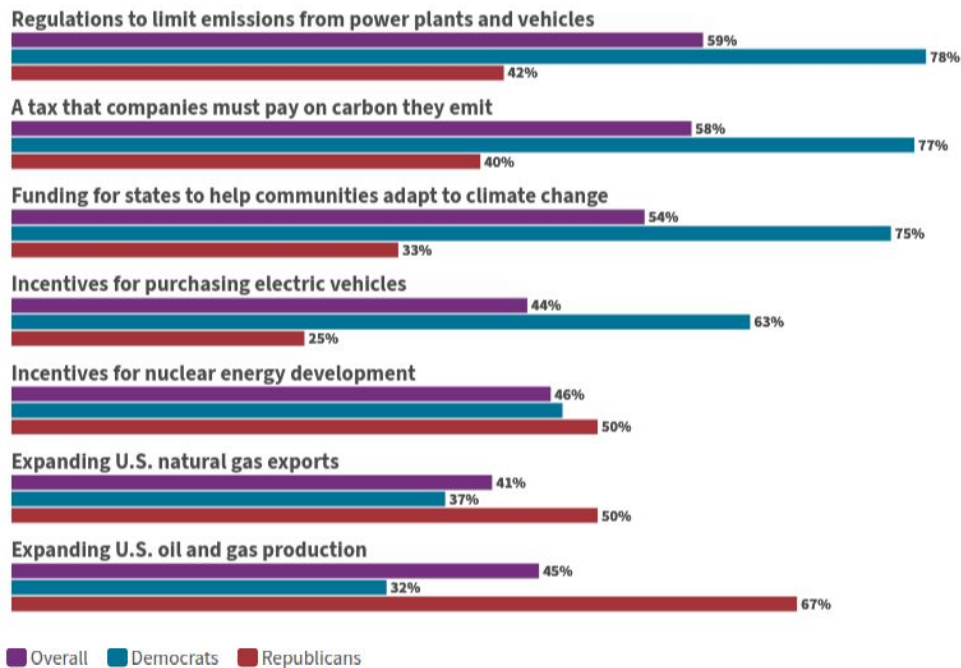


Overall Democrats Republicans

Source: EPIC-AP/NORC Public Opinion Poll

What do people think about climate change?

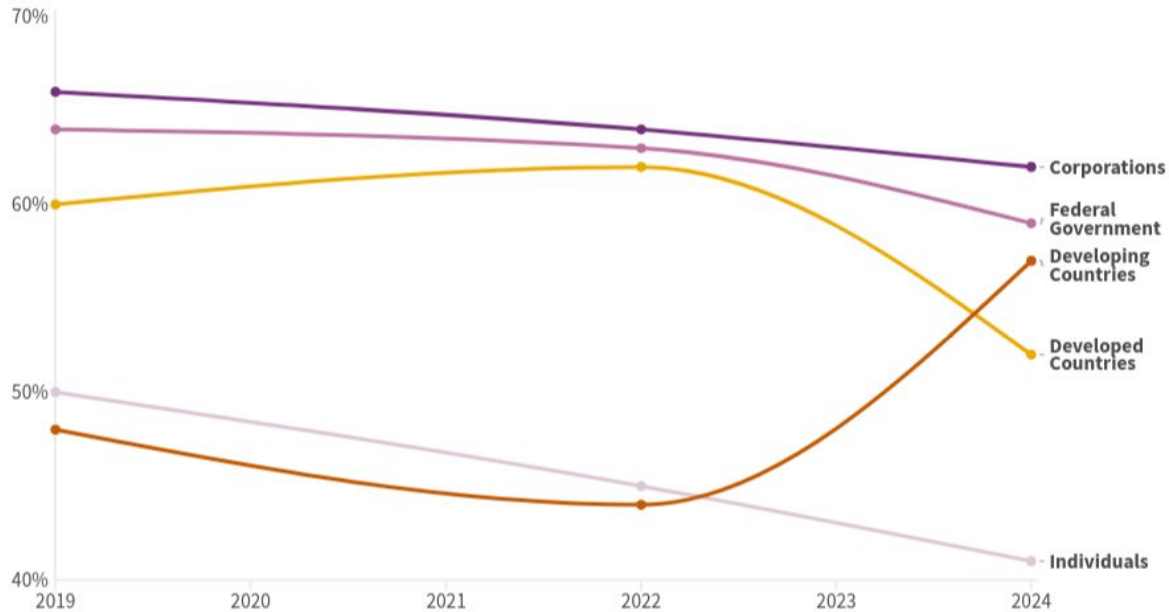
Support for climate and energy policies



Source: EPIC-AP/NORC Public Opinion Poll

What do people think about climate change?

Responsibility to act on climate change

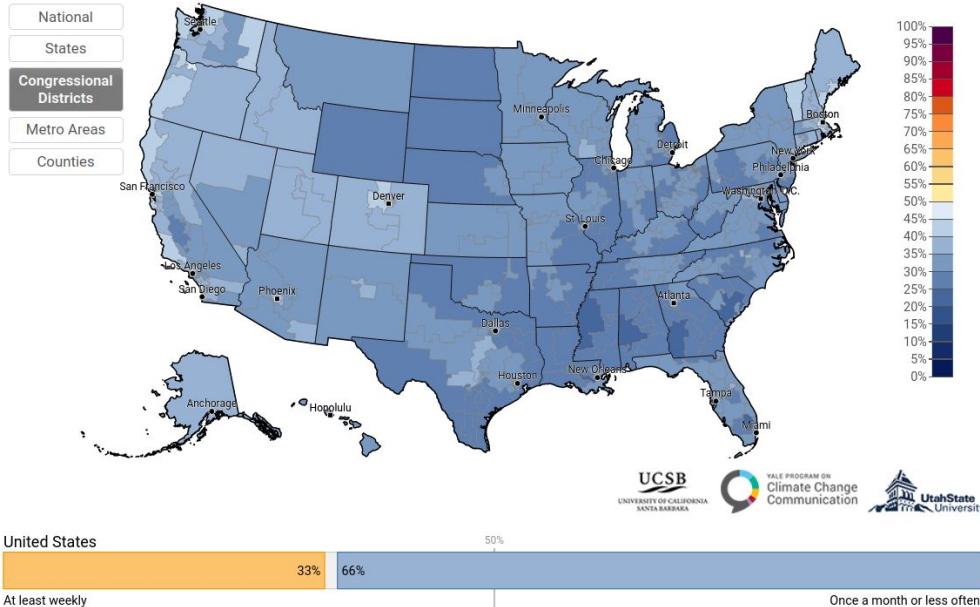


Source: EPIC-AP/NORC Public Opinion Poll • Note: While this poll asked specifically about "rapidly developing countries like India and China," previous polls asked about "developing countries."

What do people think about climate change?

Estimated % of adults who hear about global warming in the media at least once a week (nat'l avg. 33%), 2021

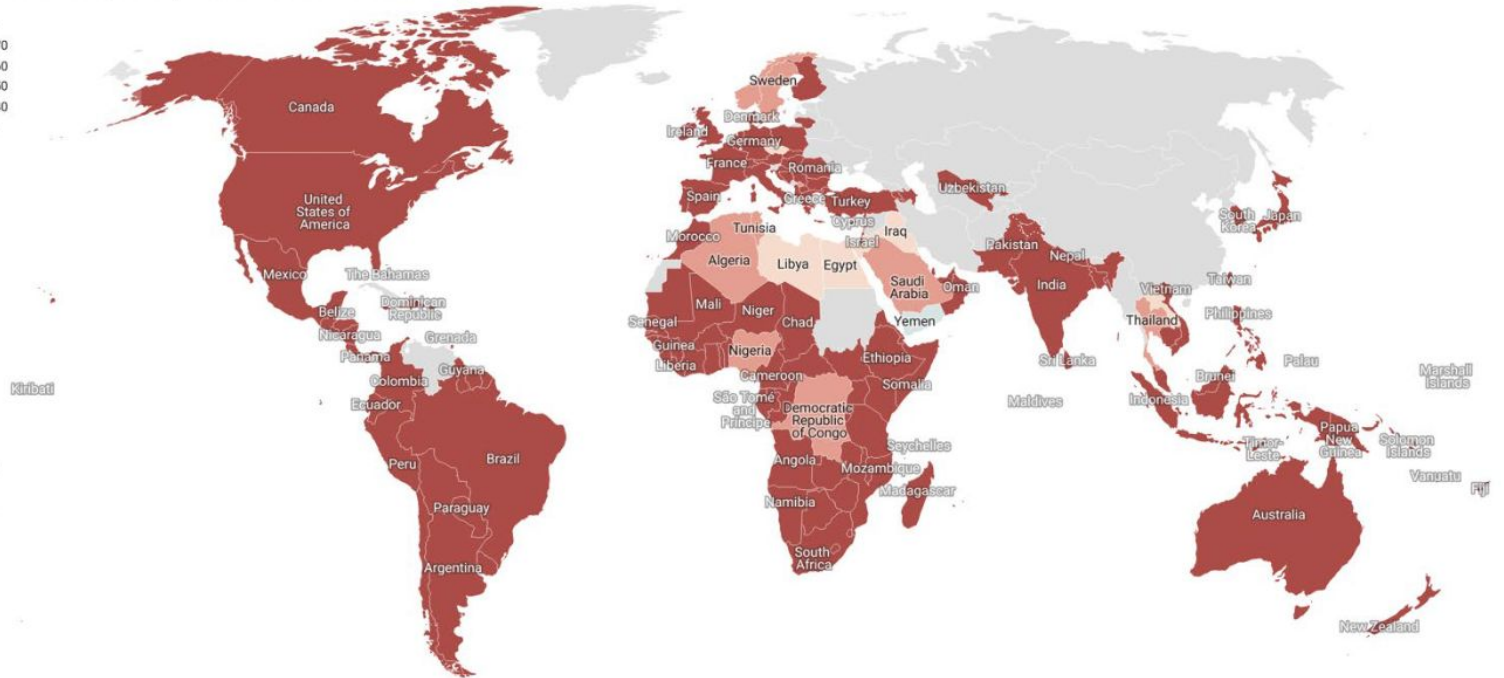
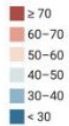
Select Question:
Click on map to select geography, or:



What do people think about climate change?

Climate change is a threat in the next 20 years

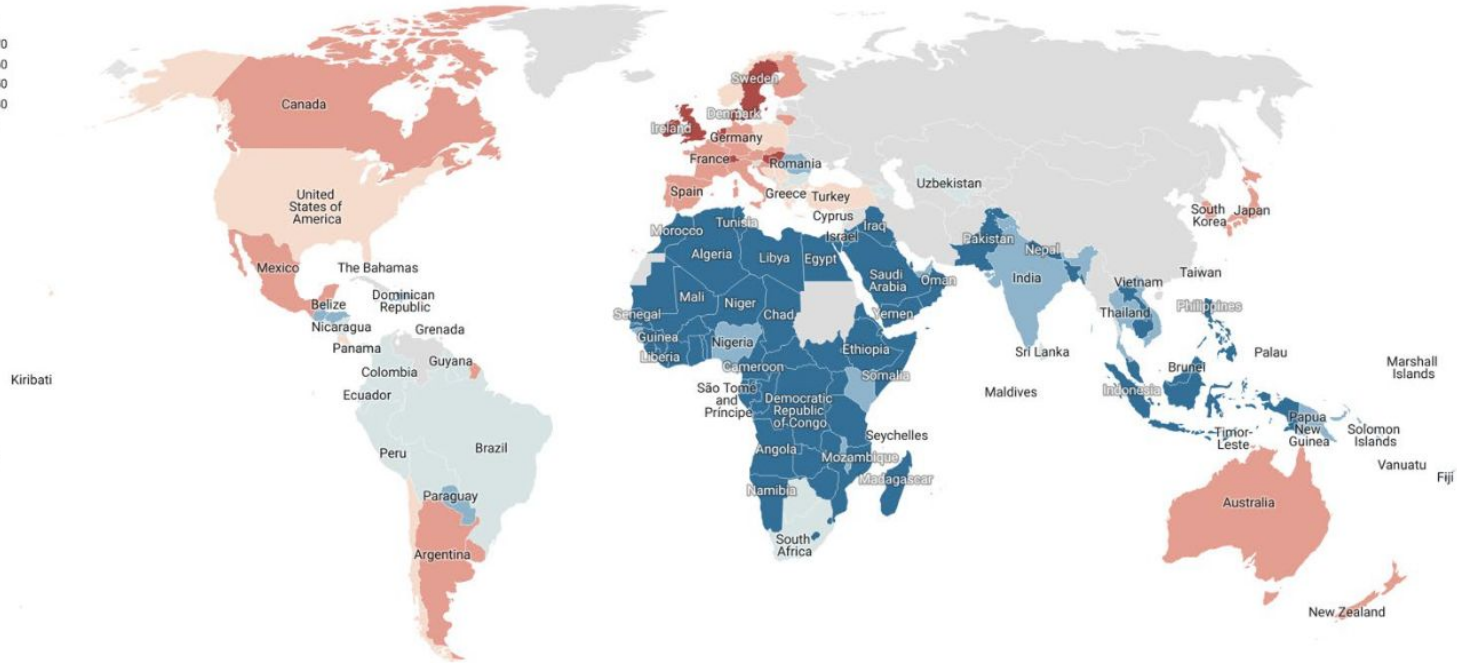
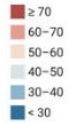
% who think climate change is a 'very' or 'somewhat' serious threat over next 20 years



What do people think about climate change?

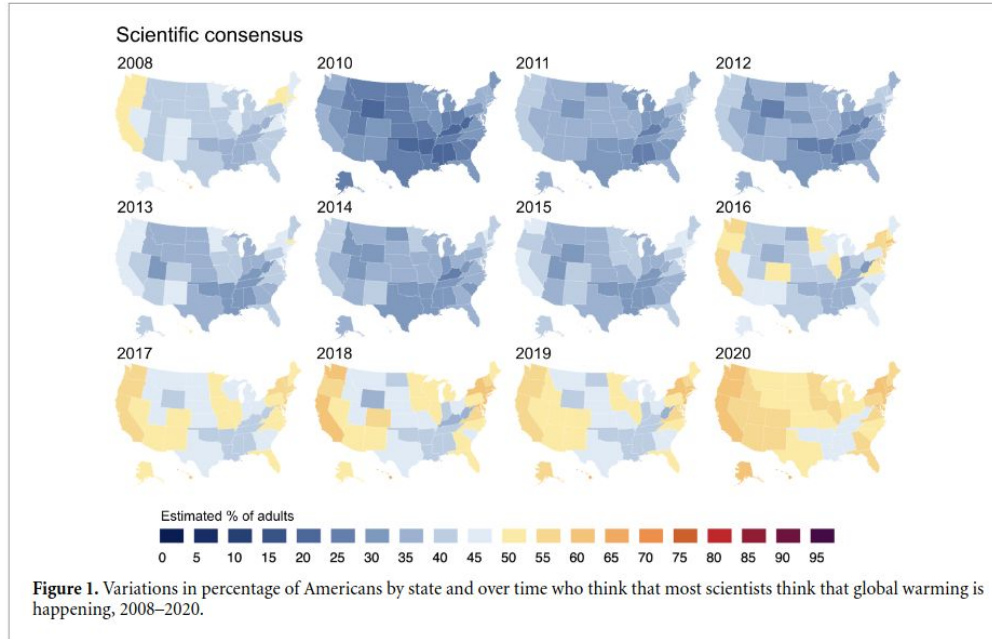
Support for reducing fossil fuels

% who support 'much less' or 'somewhat less' fossil fuels



Source: Yale Program on Climate Change Communication / Data for Good at Meta · Created with Datawrapper

Can we change people's minds?



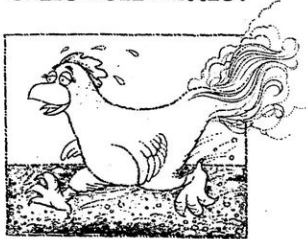
It's already been happening

Unsettled Science

Can we change people's minds?

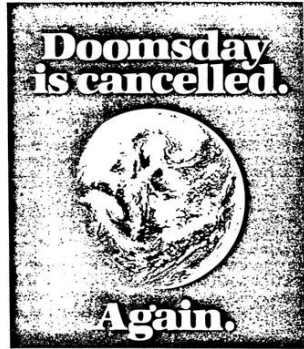
Oil companies have done it (in the wrong way)

Who told you the earth was warming... Chicken Little?



Chicken Little's worries about the sky falling were based on a few facts that have been out of proportion.

In the recent global warming, there's no hard evidence it's coming. In fact, evidence the Earth is warming is weak. Proof that carbon dioxide is causing global warming is weak. Proof that carbon dioxide has been the primary cause is inconclusive. Climate models cannot accurately predict the future global climate. And the underlying physics of climate change are still very open to debate. If you are about the earth, be don't waste your imagination to see away with you, make sure you get the facts.



The twentieth century has seen many predictions of global destruction. In the 1950s, some scientists thought we were in the middle of a disastrous warming trend. In the mid 1970s, others were sure we were entering a new Ice Age. And so on. It's the same with global warming. There's no hard evidence it's occurring. In fact, evidence the Earth is warming is weak. Proof that carbon dioxide has been the primary cause is inconclusive. Climate models cannot accurately predict the future global climate. And the underlying physics of the climate change are still very open to debate. If you are about the environment, but don't care to be persuaded into spending money on problems that don't exist, make sure you get the facts. Write: Informed Citizens for the Environment, P.O. Box 2553, Grand Forks, North Dakota 58207 or call 701/764-6473. We'll send you the facts about global warming.



Lies they tell our children

"I don't have a future."

With tears streaming down her face, a 13-year-old girl made this bleak assessment to her father. To back up her pessimism, she had brought home from school a mimeographed sheet listing the horrors that awaited her generation in the next 25 years: Worldwide famine, overpopulation, air pollution so bad that everyone would wear a gas mask, befouled rivers and streams that would mandate cleansing tablets in drinking water... a greenhouse effect that would melt the polar ice caps and devastate U.S. coastal cities... a cancer epidemic brought on by damage to the ozone layer.

Moved by the girl's misery, her father, Herbert I. London of the Hudson Institute and New York University, wrote a book, *Why Are They Lying to Our Children?* The book documents how some of the myths of the 1960s and 1970s—and some much older than that—are being perpetuated and taught as gospel truth in some of our schools. And the book raises a question in our minds: Will the next generation have any better understanding of science and technology—both their merits and their problems—than our own?

Professor London's book is not a plea for unbridled technology. But it is a plea for balance. And school teachers, he believes, are notoriously unbalanced. In dealing with environmental questions, for example, no textbook the professor could find made any mention of the following facts:

■ Total automobile emissions of hydrocarbons, carbon monoxide, and nitrogen oxide

in the U.S. are less than half what they were from 1957 to 1967.

■ The amount of unhealthy sulfur dioxide in the air has been steadily declining since 1970.

■ The bacteria level in the Hudson River declined by more than 30 percent between 1966 and 1980.

Textbooks, Professor London finds, mythologize nature as eternally benign until disturbed by man. It's a rare schoolbook that talks about volcanoes belching radiation into the air, floods that overwhelm river towns, and tornadoes that lift people into oblivion. Moreover, textbooks hardly mention the promise of a bright future already on the horizon—when average life expectancy may approach 90 years, when products derived from recombinant DNA research will eliminate most viral diseases, when we will enjoy greater leisure, and materials—especially plastics—will be better, stronger, and safer.

Professor London's conclusion—with which we heartily agree—is that we should help our children think for themselves and reach balanced conclusions. Let's look at their textbooks, not to censor them but to raise questions. Let's give them different points of view and help discuss them. That way we can educate a new generation of citizens who aren't scared by science, and who won't be swayed by old mythsologies.

Our youngsters do have a future. We, and the schools, should help them look forward to it with hope, even as they prepare to deal with its problems.

Knowing that weather forecasts are reliable for a few days at best, we should recognize the enormous challenge facing scientists seeking to predict climate change and its impact over the next century. In spite of everyone's desire for clear answers, it is not surprising that fundamental gaps in knowledge leave scientists unable to make reliable predictions about future changes.

A report from the National Research Council (NRC) raises important issues, including these still-unanswered questions:

(1) Has human activity already begun to change temperature and the climate, and (2) How significant will future change be?

The NRC report confirms that Earth's surface temperature has risen by about 1 degree Fahrenheit over the past 150 years. Some use this result to claim that humans are causing global warming, and they point to storms or floods to say that dangerous impacts are already under way. Yet scientists remain unable to confirm either contention.

Geological evidence indicates that climate and greenhouse gas levels experience significant natural variability for reasons having nothing to do with human activity. Historical records and current scientific evidence show that Europe and North America experienced a medieval warm period one thousand years ago, followed centuries later by a little ice age. The geological record shows even larger changes throughout Earth's history. Against this backdrop of large, poorly understood natural variability, it is impossible for scientists to attribute the recent small surface temperature increase to human causes.

Moreover, computer models relied upon by climate scientists predict that lower atmospheric temperatures will rise as fast as or faster than temperatures at the surface. However, only within the last 20 years have reliable global measurements of temperatures in the lower atmosphere been available through the use of satellite technology. These measurements show little if any warming.

Even less is known about the potential positive or negative impacts of climate change.

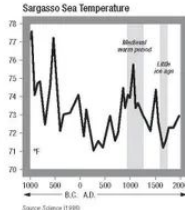
In fact, many academic studies and field experiments have demonstrated that increased levels of carbon dioxide can promote crop and forest growth.

So, while some argue that the science debate is settled and governments should focus only on near-term policies—that is empty rhetoric. Inevitably, future scientific research will help us understand how human actions and natural climate change may affect the world

and will help determine what actions may be desirable to address the long-term.

Science has given us enough information to know that climate changes may pose long-term risks. Natural variability and human activity may lead to climate change that could be significant and perhaps both positive and negative. Consequently, people, companies and governments should take responsible actions now to address the issue.

One essential step is to encourage development of lower-emission technologies to meet our future needs for energy. We'll next look at the promise of technology and what is being done today.



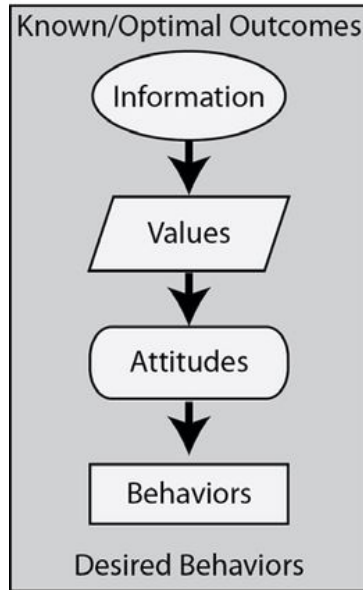
Source: Science 1999

ExxonMobil

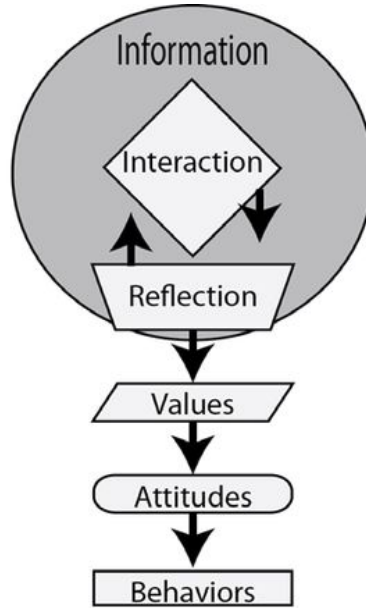
Mobil

'ExxonMobil's climate "advertisorials" – advertisements disguised as editorials – appeared in the op-ed page of the New York Times and other newspapers and were part of what scholars have called "the longest, regular (weekly) use of media to influence public and elite opinion in contemporary America".'

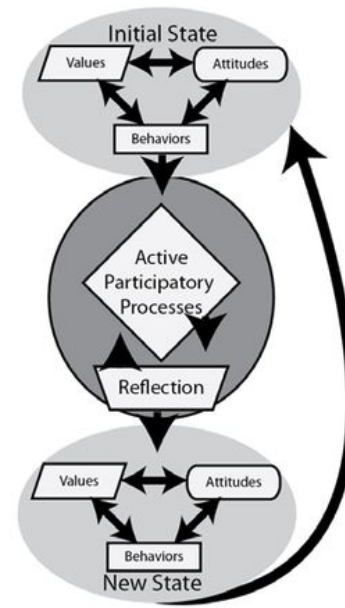
What is effective at changing minds?



Information Deficit



Procedural Rhetoric



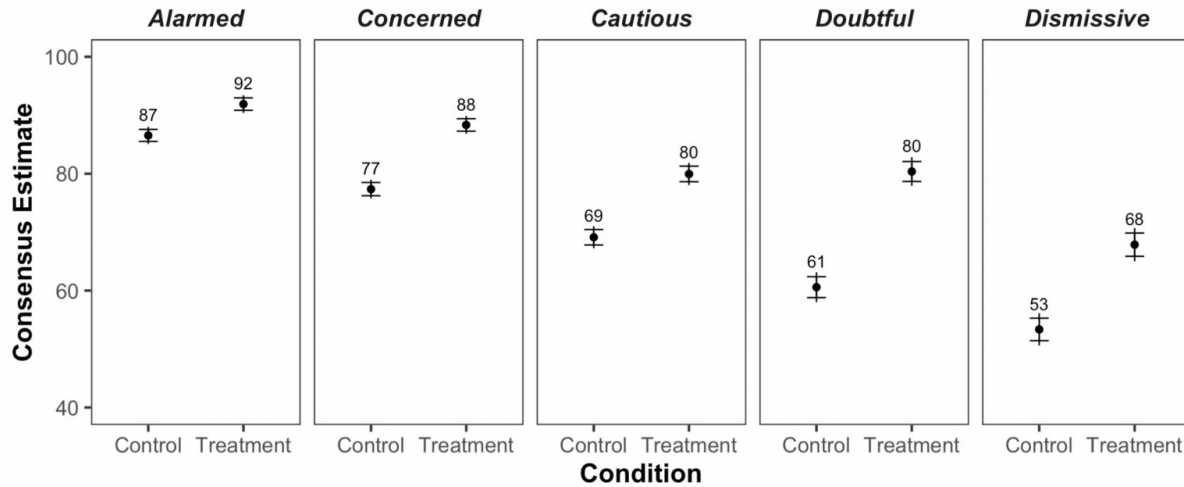
Emergent Dialogue

Ways to change minds depends on how you think minds work: The ability to change minds and behaviors can depend simply on providing information, or may require more involved processes of interaction and activations of a sense of identity

What is effective at changing minds?

Enforcing that there is scientific consensus

Estimates of the scientific consensus across conditions and audience segments



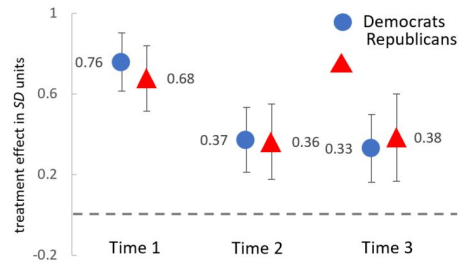
“We delivered a consensus message (i.e., “97% of climate scientists have concluded that human-caused global warming is happening”) to members of five of the six U.S. climate audiences. We found that all audiences – from *Alarmed* to *Dismissive* – updated their beliefs about the scientific consensus.”

Note. Vertical error bars represent 95% confidence intervals. Horizontal error bars represent 83% confidence intervals to facilitate visual comparisons of significant differences at $p = .05$. Values are means adjusted for pre-treatment estimates of the scientific consensus.

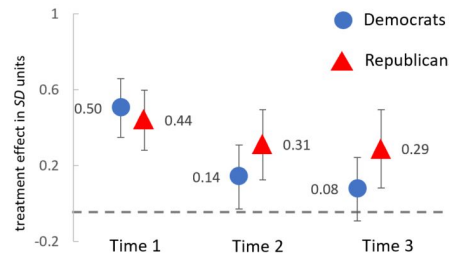
What is effective at changing minds?

Emphasizing co-benefits

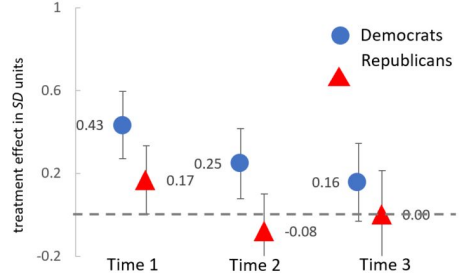
A. Cost Savings Frame



B. Economy & Jobs Frame



C. Global Warming Frame



The three panels show the effect of each of the three frames (Panel A = Cost Savings Frame; Panel B = Economy & Jobs Frame; Panel C = Global Warming Frame). The values in each panel represent the size of the effect (y-axis) of that frame on beliefs about that benefit of renewable energy, for Democrats and Republicans separately.

The x-axis shows how the size of these persuasive effects decayed over time. Time 1 measurement was immediately after viewing the message. Time 2 was an average of 11 days after Time 1. Time 3 was an average of 23 days after Time 1. Error bars indicate 95% confidence intervals around the mean.

What is effective at changing minds?

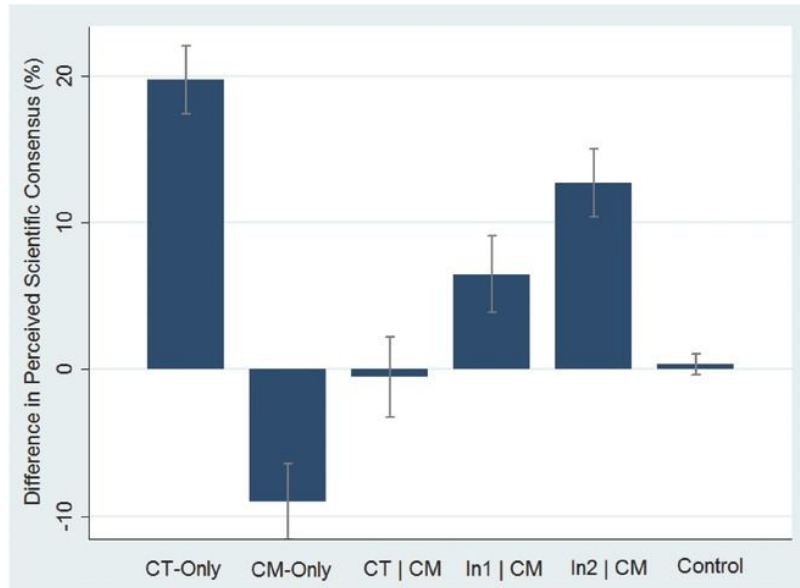
Changing actions can change beliefs

In fact, taking action with concrete solutions can actually help change minds. “Belief and action are connected,” said anthropologist Ben Orlove, co-director of the Earth Institute’s [Center for Research on Environmental Decisions](#). “Belief is often a basis for action. But once you’re committed to a course of action, you tend to find lots of reasons for why you did it.”

Hayhoe told a story that illustrates just this point. For years, her colleague argued the science of climate change with his father who was a long-time doubter, but he was never able to change his father’s mind. Finally the local community offered a big rebate to get solar panels, so the father installed them on his house. One year later, after telling everyone what a good deal it was and how much money he had saved, the father came to Hayhoe’s colleague and said, “You know, that climate thing might be real after all.”

What is effective at changing minds?

‘Inoculation’ against known misinformation



Note: CT = Consensus Treatment, CM = Counter-Message, In1 = General Inoculation, In2 = Detailed Inoculation. Error bars represent 95% confidence intervals.

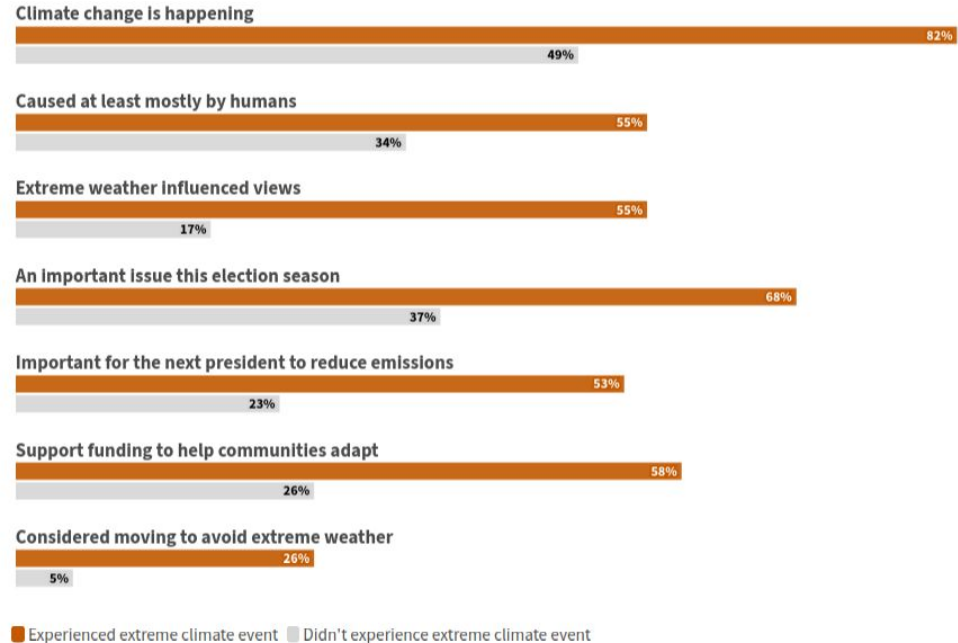
Letting people know that politically-motivated actors are spreading misinformation about climate change (In1 and In2) can reduce the impact of that misinformation.

<https://onlinelibrary.wiley.com/doi/full/10.1002/gch2.201600008>

What is effective at changing minds?

Personal experience
with the effects of
climate change

Beliefs of those who have experienced extreme climate events



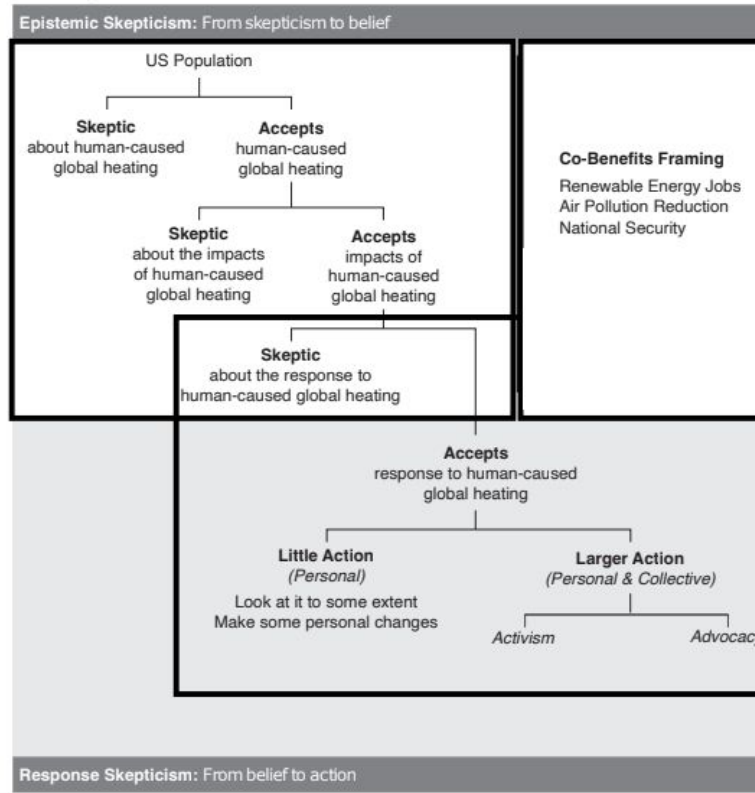
Source: EPIC-AP/NORC Public Opinion Poll • Note: In the 2024 poll, respondents were asked: In the past 12 months, has your local community experienced each of the following, or not? [Unusually hot or cold days; Severe storms, including hurricanes; Flooding; Droughts and water shortages; Wildfires; Poor air quality]. The 2023 poll asked a slightly different question: In the past 12 months, has your local community experienced an extreme weather event such as a hurricane, drought, flood, unusual heat or cold, or wildfires, or not?

Three ways to get a broader social mobilization:

Shift the skeptics to belief

Shift the believers to action

Leverage co-benefits to get policy support

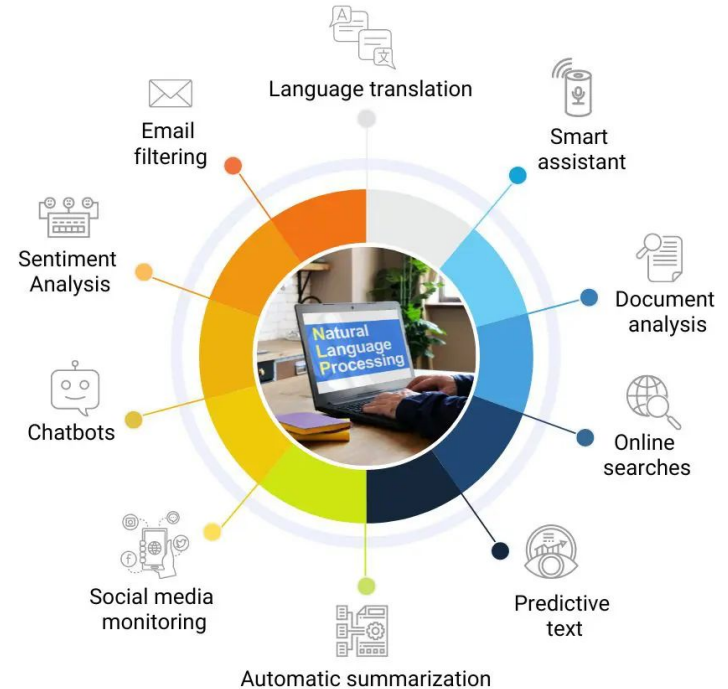


Natural Language Processing

NLP requires building algorithms that can make sense of text.

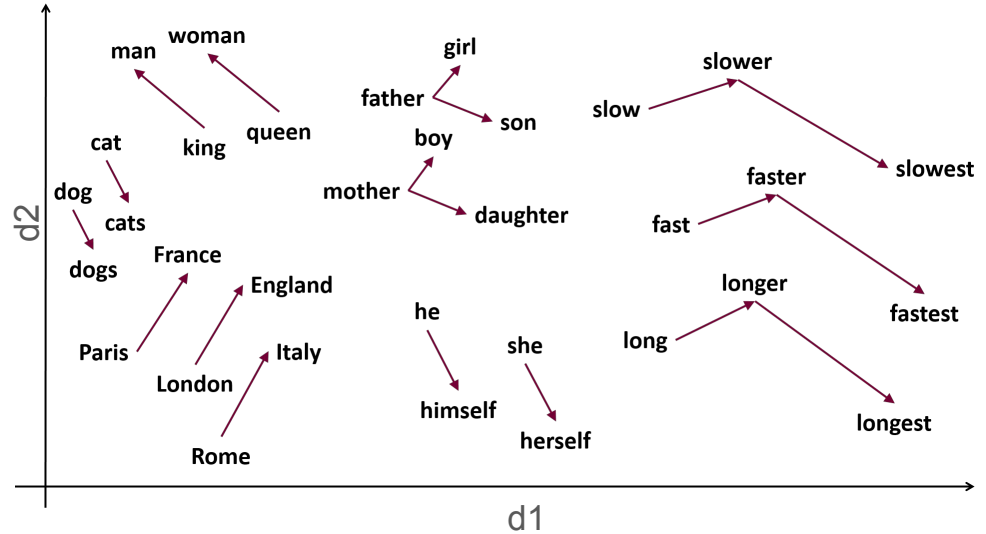
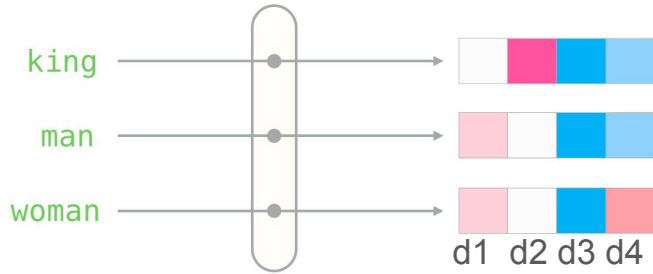
NLP tasks can be incredibly challenging due to the diverse ways in which people use language and how language relates to the real world.

Applications of Natural Language Processing



Natural Language Processing

Requirement: Represent meaning as a vector of numbers



Natural Language Processing

Requirement: Represent meaning as a vector of numbers

Simplest approach = represent words in terms of how often they co-occur with other words.

	Roses	are	red	Sky	is	blue
Roses	1	1	1	0	0	0
are	1	1	1	0	0	0
red	1	1	1	0	0	0
Sky	0	0	0	1	1	1
is	0	0	0	1	1	1
Blue	0	0	0	1	1	1

What are the limitations of this?

Modern Approach

Use a “Large Language Model” (LLM)

BERT: “Bidirectional Encoder Representations from Transformers”

Attention Is All You Need

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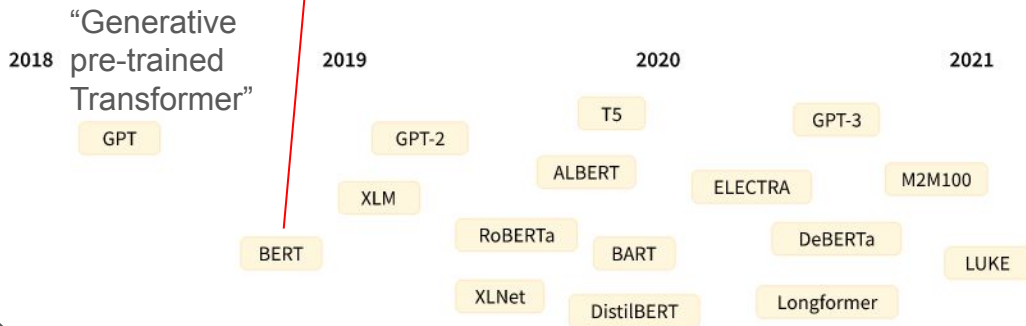
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Abstract

The dominant sequence transduction models are based on complex recurrent or convolutional neural networks that include an encoder and a decoder. The best performing models also connect the encoder and decoder through an attention mechanism. We propose a new simple network architecture, the Transformer, based solely on attention mechanisms, dispensing with recurrence and convolutions entirely. Experiments on two machine translation tasks show these models to be superior in quality while being more parallelizable and requiring significantly less time to train. Our model achieves 28.4 BLEU on the WMT 2014 English-to-German translation task, improving over the existing best results, including ensembles, by over 2 BLEU. On the WMT 2014 English-to-French translation task, our model establishes a new single-model state-of-the-art BLEU score of 41.0 after training for 3.5 days on eight GPUs, a small fraction of the training costs of the best models from the literature.

Here are some reference points in the (short) history of Transformer models:



The Transformer architecture was introduced in June 2017. The focus of the original research was on translation tasks. This was followed by the introduction of several influential models, including:

“Foundation Models”

As we saw previously, we can use transfer learning/fine-tuning on a pre-trained model to solve tasks where data is limited.

Foundation models take this idea to the extreme.

— WHAT IS A FOUNDATION MODEL?

In recent years, a new successful paradigm for building AI systems has emerged: Train one model on a huge amount of data and adapt it to many applications. We call such a model a foundation model.

— WHY DO WE CARE?

Foundation models (e.g., GPT-3) have demonstrated impressive behavior, but can fail unexpectedly, harbor biases, and are poorly understood. Nonetheless, they are being deployed at scale.

Our Mission

The Center for Research on Foundation Models (CRFM) is an interdisciplinary initiative born out of the Stanford Institute for Human-Centered Artificial Intelligence (HAI) that aims to make fundamental advances in the study, development, and deployment of foundation models.

We are an interdisciplinary group of faculty, students, post-docs, and researchers spanning 10+ departments who have a shared interest in studying and building responsible foundation models.

CRFM has the following thrusts:

- **Research.** We will conduct interdisciplinary research that lays the groundwork of how foundation models should be built to make them more efficient, robust, interpretable, multimodal, and ethically sound.
- **Artifacts.** We will train and release foundation models, code, tools, and also ensure that the full training pipeline is reproducible and scientifically rigorous.
- **Community.** We will invite universities, companies, and non-profits to convene and work together to develop a set of professional norms for how to responsibly train and deploy foundation models.

Essentially, foundation models *learn good representations*.

Energy consumption of foundation models

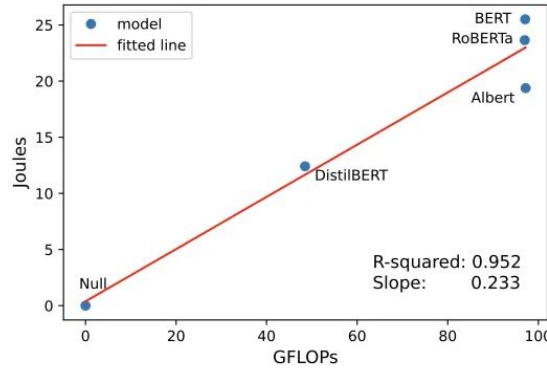
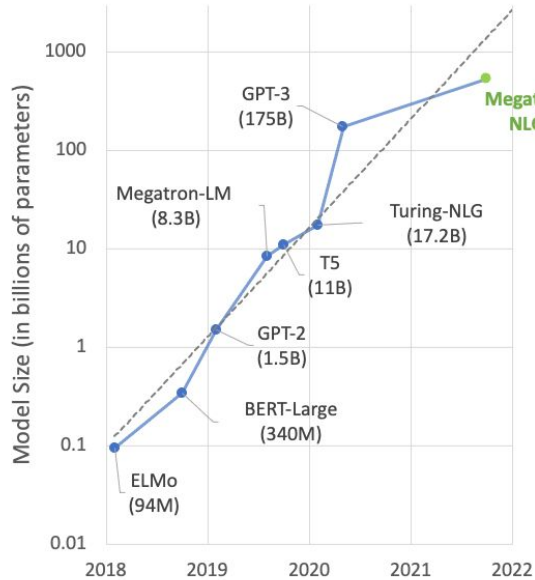
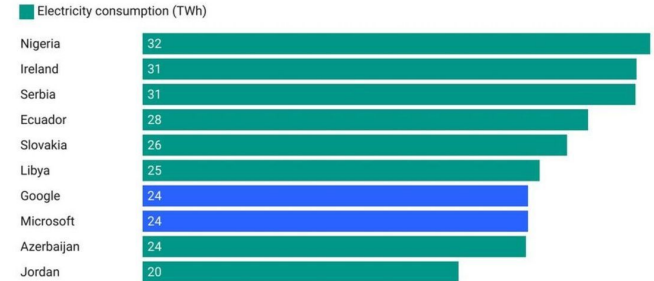


Fig 5: Regression line on CPU energy consumption per step

Google and Microsoft now consume more electricity than 100+ countries

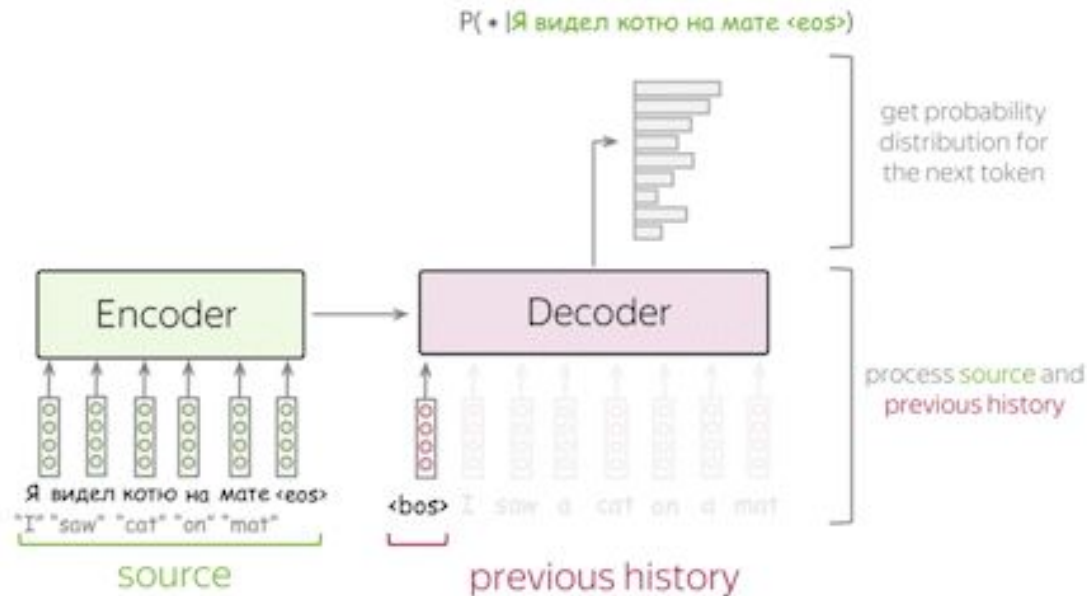
In 2023, the two tech companies both consumed 24 TWh of electricity, more than the entire country of Iceland consumed.



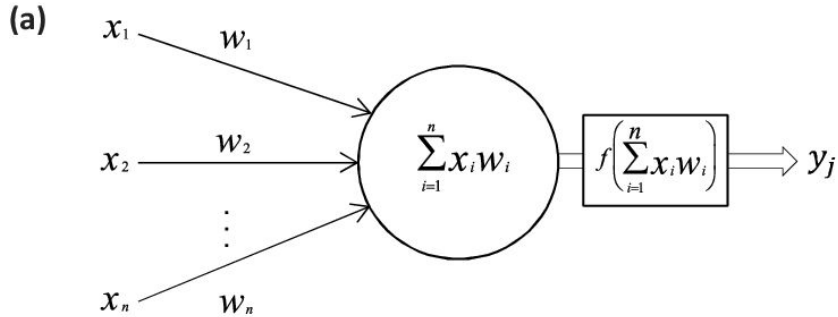
Google and Microsoft consume more electricity than 100+ countries
(Image credit: Michael Thomas)

Architecture of a Large Language Model

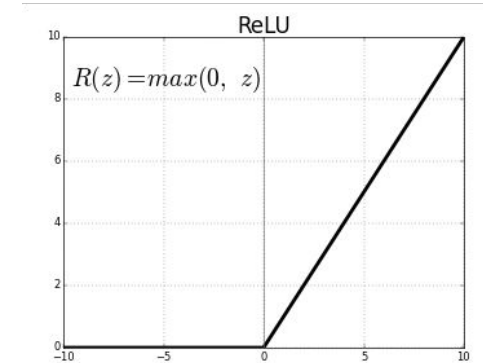
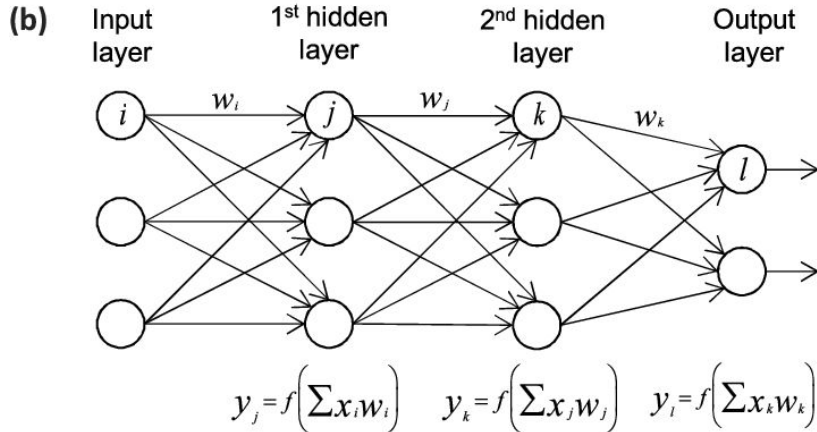
Many language tasks are “sequence to sequence” problems that can be solved with an encoder and decoder. The encoder and decoder are each artificial neural networks



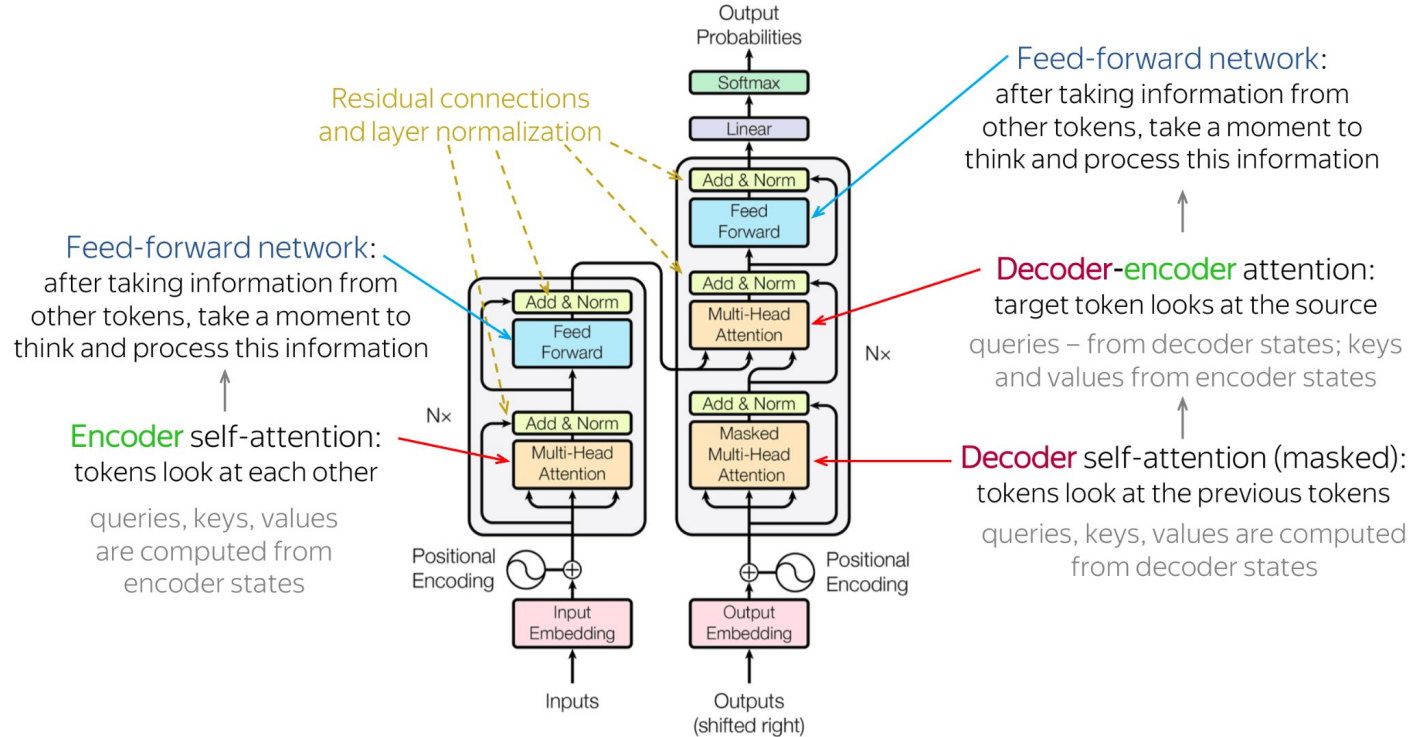
Neural networks



Basic or “vanilla” networks
multiple weights by node activity,
sum these values, and rectify the
sum.



Transformer architecture



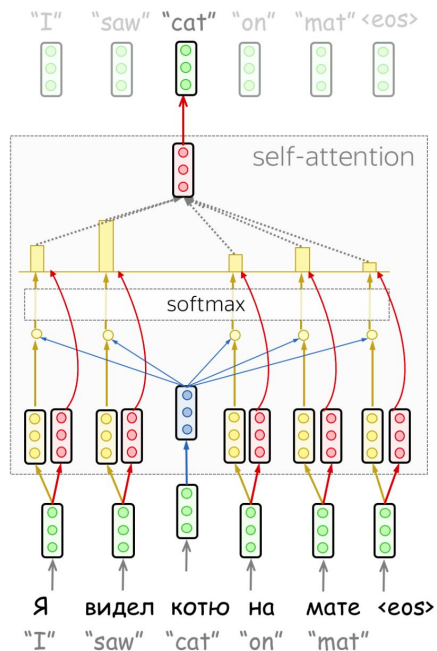
Transformer architecture

Each vector receives three representations (“roles”)

$[W_Q] \times \begin{bmatrix} \bullet \\ \bullet \\ \bullet \end{bmatrix} = \begin{bmatrix} \bullet \\ \bullet \end{bmatrix}$ **Query:** vector from which the attention is looking
 “Hey there, do you have this information?”

$[W_K] \times \begin{bmatrix} \bullet \\ \bullet \\ \bullet \end{bmatrix} = \begin{bmatrix} \bullet \\ \bullet \\ \bullet \end{bmatrix}$ **Key:** vector at which the query looks to compute weights
 “Hi, I have this information – give me a large weight!”

$[W_V] \times \begin{bmatrix} \bullet \\ \bullet \\ \bullet \end{bmatrix} = \begin{bmatrix} \bullet \\ \bullet \\ \bullet \end{bmatrix}$ **Value:** their weighted sum is attention output
 “Here’s the information I have!”



Key insight: combine information across words. This is known as “self-attention”.

I arrived at the **bank** after crossing thestreet? ...river?
 What does **bank** mean in this sentence?



RNNs

$O(N)$ steps to process a sentence with length N



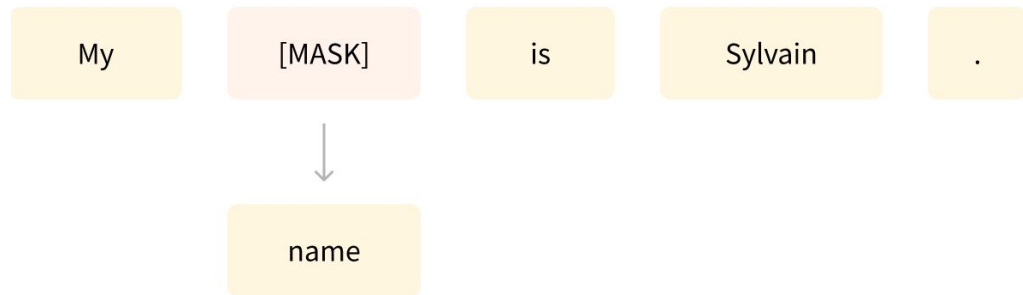
Transformer

Constant number of steps to process any sentence

LLMs can be trained on many different tasks

For example: language translation or next word prediction (ChatGPT)

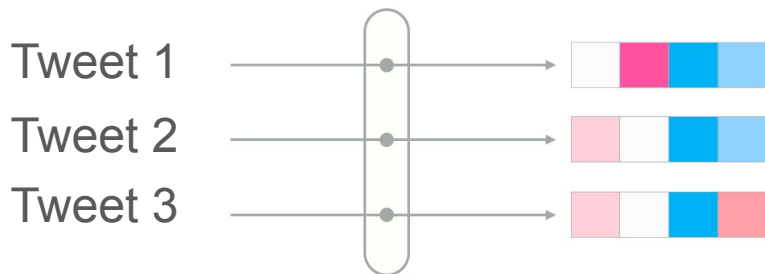
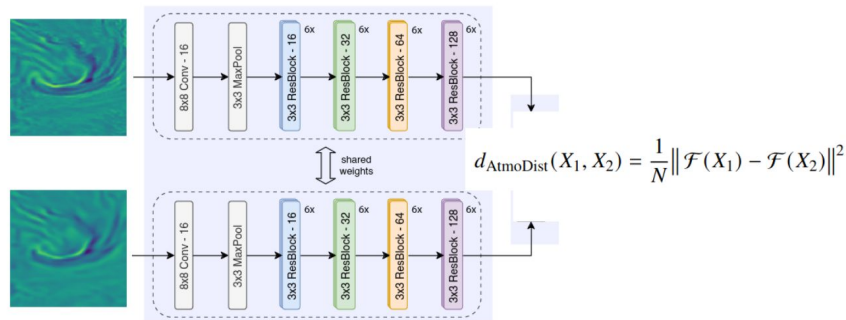
BERT is trained with a “masking” task: predict hidden word.



The LLM gives us a new representation

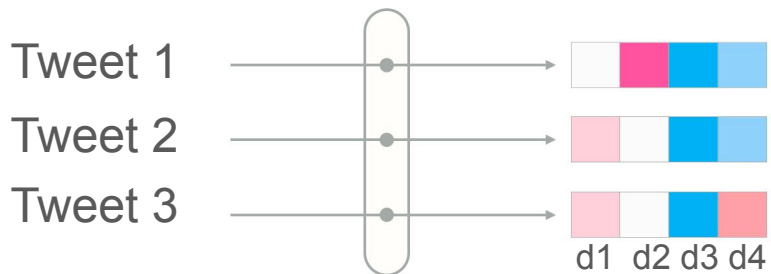
This is also known as the “embedding space”

	Roses	are	red	Sky	is	blue
Roses	1	1	1	0	0	0
are	1	1	1	0	0	0
red	1	1	1	0	0	0
Sky	0	0	0	1	1	1
is	0	0	0	1	1	1
Blue	0	0	0	1	1	1

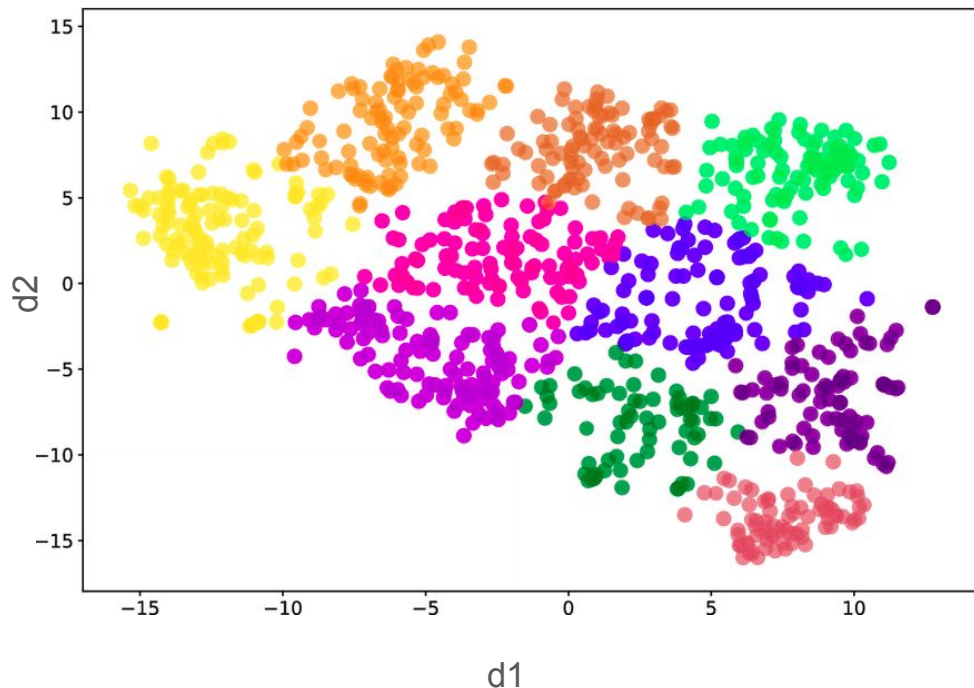


The LLM gives us a new representation

We can do things in that space, like unsupervised clustering



The output of the clustering gives us a new “topic” based representation we can use for downstream tasks



For your reading and your homework:

In machine learning settings where hyperparameters need to be set, data is typically divided into three subsets:

Training - data you actually pass to the algorithm that it uses to update weights

Validation - data you use to test the performance of models with different hyperparameters

Test - data you use to evaluate your model once you have decide on the hyperparameters

Project Plan Homework

Each member of your team should submit the same document to Brightspace by **11:59pm on April 1st**.

The document should include:

A team name you make up

The names of all team members

A summary of your project plan (details on next slide)

A statement verifying that you have downloaded, opened, and explored the dataset you plan to use

I will provide feedback about your plan the day after it is due

Project Plan Homework

Summary: Do a modified PMIRO for your own research.

State the **problem** you will try to solve and how it relates to climate change.

Describe the **methods** you will try on the problem and why they are appropriate for the data you have chosen (include the specific data you will be working with).

State how your planned work is **substantial** enough for the project. Describe how you will **evaluate** the model for your results. Discuss **issues you anticipate** encountering (will a lot of data cleaning be required, will you need to do a lot of hyperparameter testing, are you working with something you've never used before, etc).

Projects - Reminder

Rough guidelines for creating a **substantial** project:

- Compare multiple methods and/or hyperparameters
- Use at least one method that isn't in scikit-learn (Rijul will be going through PyTorch code in labs)
- Explore feature importance methods
- Create your own dataset from multiple sources
- Use multiple evaluation methods
- Include advanced visualizations and/or a dashboard (but it better be really good)
- etc

Look at last week's slides!