Improving Climate Change Cognition

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Chapter 1

Introduction

1.1 The problem

Various human efforts, over the course of history, have drastically improved the comprehensibility of our world. Along with this, the scope of our power to alter our world has increased dramatically.

The results of these efforts are understood and produced by few, and consumed by many.

A pervasive shortcoming is our tendency to discount the long-term costs of behaviors that are immediately rewarding. For example eating unhealthy (but delicious) food is enjoyable in the short term, but has obvious cumulative effects. The cost of a single donut, for example, is a trivial effect on our health, but over time, these small choices add up.

Similarly, behaviors that may ultimately have disastrous consequences on the environment are immediately rewarding. Taken individually, any given action is unlikely to have a measurable effect on, say, global mean temperature.

Questions of how to govern a democratic society.

Increase of financial influence in the democratic process.

In summary, the scope of climate change cognition is far too broad for a research project of only a few semesters. As such, I will focus on a few issues that are of interest from a cognitive theory of learning point of view, as well as being of some centrality to an educational point of view. I start out with a pragmatic sense of "poor" and "good" cognition regarding climate change and related conceptual domains. The goal is to obtain an understanding that allows us to shift individuals from the former to the latter. Roughly speaking, this might include:

1. Fluency with models used to explain and predict climate change
2. Evidence-based reasoning
3. Skeptical evaluation of evidence offered by others
4. Ability to connect one's personal values and beliefs to policy preferences

Hypotheses:

1. Increased knowledge and understanding will yeild greater acceptance of climate change (and similarly with evolution)
2. Emotional engagement will play a role in climate change acceptance or rejection, as well as enhancing learning
3. Surprise will enhance learning

There is a sharp distinction between the kinds of "emotional responses" that might be experienced between climate change and global warming. Specifically, climate change is something that involves the ethical status of actions that we do every day, both individually and as a society. Evolution, on the other hand, tends to incohere with personally held religious beliefs, most directly divine creation, but then by extension, deity and afterlife.

Ultimately, the structure of this thesis harkens back to early psychophysical research. There are a number of factors that we are certain will induce surprise, learning and acceptance of novel ideas. Questions take the form of

So, more specifically, I expect:

1. "Rational" bases for a belief or attitude will result in more durable shifts, both against the passage of time, and against interference or agnotology
2. Emotional responses will trigger larger shifts in attitudes, or increase the likelihood of change in attitudes and learning in general
3. No single point of entry will be necessary - changing behavior, appeal to emotions or provision of rational argument should all be sufficient to have some effect on their own
4. Multiple methods of engagement in parallel should interact to yeild greater shifts / learning than the sum of those methods individual effects

Overall, the general question is

1.2 Reinforced Theistic Manifest Destiny theory

Brief description of Michael's RTMD theory. Include a figure.

I'll go one step further than Ranney's explication of these ideas and suggest that they have a more "implicit" than "explicit" flavor. That is, most likely don't explicitly consider, say, their feelings of national pride when cognizing about evolution. Thus, interventions that operate more on "implicit" or "automatic" aspects of, say, nationalism (i.e., via emotionally charged items as compared to more objective items) may enhance the effect on relations as compared to shifts in the attitudes themselves.

Another general problem identified within RTMD is the fact that individuals often reject scientific ideas when they are in conflict with their other attitudes and beliefs. It's as if we are endowed with something of a conceptual immune system, comprising religious and nationalistic beliefs in some, and more scientifically grounded beliefs in others.

1.3 Reasoning with Numbers

The education and social psychology literature provide multiple examples of failures to elicit conceptual change. For example, in Chi (2005), only 1 in 100 eighth-graders were able to shift to a correct conceptual model of diffusion. Similar examples are available in a variety of literatures (diSessa & Sherin, 1998; Lord, Ross, & Lepper, 1979, cf.). NDI procedures yield notable and encouragingly long-lasting levels of conceptual change with quite minimalist interventions (e.g., providing estimators with a single, critical, highly germane, feedback statistic; Rinne, Ranney, & Lurie, 2006, cf.. The Numerically Driven Inference (NDI) paradigm (Ranney, Cheng, Osuna, & Nelson, 2001, introduced by) to study and foster numeracy.

The EPIC procedure represents an intervention that is relatively compact and well specified. More importantly, EPIC has been shown to induce long-lasting conceptual change (e.g., Ranney et al., 2008), as evidenced by increased accuracy on estimations up to 12 weeks later (Munnich, Ranney & Bachman, 2005). In the EPIC procedure, participants engage with real-world numerical facts that bear on a societal issue, such as abortion, criminal justice, the environment, etc. (e.g., Garcia de Osuna, Ranney & Nelson, 2004; Munnich, Ranney, Nelson, Garcia de Osuna & Brazil, 2003). People often poorly estimate these quantities, such that the true values are surprising to many individuals, and experimental research on NDI has provided the basis for successful classroom curricula for both high school students and graduate students in journalism (Munnich, Ranney & Appel, 2004; Ranney et al., 2008). During the EPIC procedure, participants

1. provide an **Estimate** for each policy-relevant item,
2. state what they would **Prefer** each quantity to be,
3. receive actual quantities as feedback to **Incorporate** (as new Information), and
4. indicate whether their preferences have **Changed** upon receiving feedback.

The success spawned by EPIC (and its sibling procedures) may encourage education researchers, so it is important to consider the degree to which various plausible factors contribute to that success.

1.4 Two kinds of cognition

our cognition is the outcome of at least two radically different learning processes. on one hand, we learn from our life experiences. on the other, we are endowed with cognitive mechanisms that have been selected over the course of our evolutionary history. depending on the needs of a given behavior, learning might be better handled by a relatively stable, fast, local (encapsulated) or “hard-wired” cognition (note, this corresponds roughly with the “slow” system in the language of smith and shadmehr). alternatively, other behaviors might require integration of a variety of sources of information, complex processing, “random” access to relevant memories and the flexibility to construct novel mental models.

the literature on judgement and decision making reveals a large number of biases (e.g., gigerenzer, kahneman and tversky)

just because a bias fails to produce optimal results does not mean that it isn't learned from life experiences. a salient example is cultural norms, which can be highly maladaptive.

1.5 Proposed questions and hypotheses

For the scope of this thesis, I propose to answer the following questions:

1. How do numerically-grounded or mechanistic sets of facts compare to alternative methods of persuasion? For example, appeals to emotion, non-quantitative depictions of negative consequences and ethical arguments.

2. How do relationships with other attitudes (as in RTMD) affect changes in climate change cognition?

Chapter 2

Experiment: Assessments of Climate Change Cognition

At present, our group has obtained responses both for 103 berkeley undergraduates, and about 50 from a class at UT, Brownsville. For now, I have only prepared results from the Berkeley undergrads. I suspect it is unlikely that individuals experienced the same kind of "visceral" surprise from the blurb that can be obtained by, for example, statistics we've used regarding things like abortion and the death penalty. And, while it may be due to a limitation of imagination, I have difficulty imagining an evolution item that would elicit this kind of surprise.

Chapter 3

Experiment: Two Routes to Improved Numerical Estimation

In Clark and Ranney (2010), we provide some preliminary evidence and argumentation for separable learning processes which might be differentially involved when learning numerical information. Below, I present an overview of two experiments in abbreviated form, noting those details which are relevant to the questions posed above.

3.1 Overview

In short, participants saw textual descriptions of numeric items and provided their best estimate. After this, they received the true value, and indicated the degree to which they found the true value *surprising*. After a period including at least one night's sleep, participants were presented with the previously shown textual descriptions. Here, participants indicated their *metacognitive assessment of their memory* from the item from the day before, in addition to re-estimating (or potentially recalling) the value.

3.2 Experimental Methods

The following experiment was designed to assess whether estimative improvement occurs even with respect to items for which no feedback was receivedas was found in curricular NDI studies (e.g., Munnich et al., 2004; Ranney et al., 2008). The experiment (1) addresses the effects of surprise and the timing of feedback on subsequent improvements in numerical estimationas well as (2) probes whether these improvements are necessarily mediated by explicit recollection. A subset of the EPIC procedure was used to explore these issues; participants engaged only in estimation ("E") and feedback ("I"), leaving aside personal preference ("P" and "C").

3.2.1 Participants

Twelve people (seven female) participated, including UC Berkeley undergraduates and members of the general public recruited via online recruitment systems (RPP and RSVP). They received either course credit or $20 for their participation in two one-hour sessions over two consecutive days. Ages ranged from 18-56 years.

3.2.2 Materials

Numerical facts (106 of them) were selected from Ranney et al.'s (2008) collection. An example is "The current percentage of deaths in the U.S. that are caused by lung cancer." Three statistical facts were set aside for the basis of example items (namely US population, world population, and US Gross National Income). Items ranged over a number of topics, and included politics, population dynamics, economics, the environment, education, crime etc. Most items were expressed in percentage form, with the rest being counts of dollars, people, events or things. For numbers above 999, a comma was used, as in "13,600." For numbers in the millions, billions, or trillions, the appropriate word was used to indicate the order of magnitude (e.g., "300 million"). This was intended to minimize possible confusions about the exact value of the number.

3.2.3 Procedure

Custom software utilizing Vision Egg (Straw, 2008) presented all materials and collected responses. (Source code available upon request,) Descriptions of numerical facts were presented in 1-4 lines of text (with less than 55 characters per line). A prompt for numeric entry was located below the description. Feedback concerning the veridical value was provided in a third location, between the description and the text-entry area.

Blocks of Items

Items were randomly distributed into the following four kinds of blocks. Each of these blocks was involved in two or more runs over the course of the experiment. E: Participants only provided Estimates in a single run. EI: Participants provided Estimates followed immediately by correct numerical Information as feedback (i.e., feedback was provided in the same run as the initial estimation). E_I: Participants provided Estimates, then received correct numerical Information in a run that was well-separated from the run in which they provided their Estimate (i.e., "_" signifies a temporal delay). New: A block of items was reserved in both experiments to provide a gauge of false recognition or false recollection.

Experimental Runs

Participants engaged in a number of self-paced runs on each of the two consecutive days, as Figure 3.1 depicts. The presentation of stimuli and responses made were uniform across a given run. During the first day, analogous to a "study" phase, participants completed three

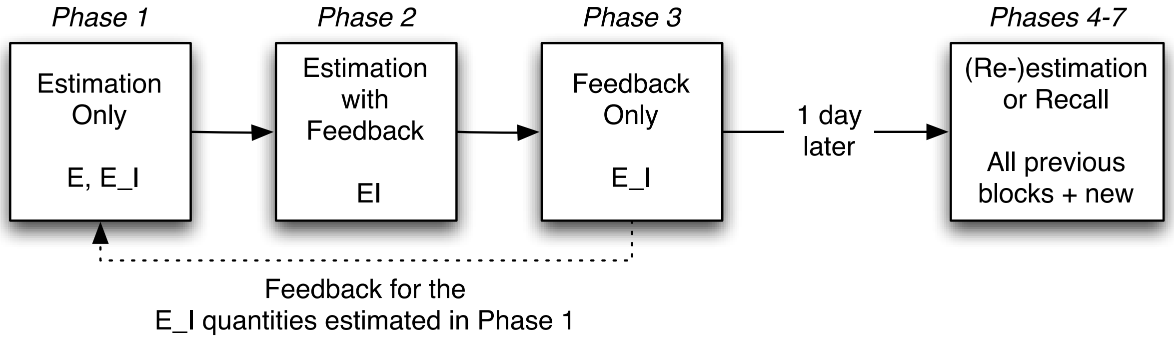

Figure 3.1: A schematic of the experiment's seven runs. Run 1: Estimates were obtained for the E and E_I blocks of items (23 each), randomly intermixed in one run. Run 2: Participants provided 23 Estimates that were immediately followed by Informing the participant of the correct value. Run 3: Feedback (I) was provided for the 23 items from the E_I block that had been Estimated in Run 1. Runs 4-7: Subjects estimated (or recalled) quantities and provided explicit memory ratings for all previous items as well as 34 new items.

partially similar runs of numerical estimation and/or informative feedback. The second day was analogous to a "test" phase, in which participants learning was assessed.

During estimation (Runs 1 and 2, with 23 items each), subjects were given a textual description of an items quantity, followed by a prompt to provide an estimate. For Run 2, feedback was provided 500 milliseconds after each estimate was entered. For Run 3 (with 23 items), the correct numerical value was provided prior to the textual description in order to minimize covert estimation.

In Runs 2 and 3 (thus, for blocks including "I"), surprise ratings were elicited regarding the values given as feedback. Three possible levels of surprise were collected: (1) Little or no surprise, (2) Genuine surprise , or (3) "Visceral" or intense surprise.

On day 2, trials were similar to the estimation-only trials in Run 1 described aboveno additional feedback was provided. An additional 34 items from the "new" block were randomly intermixed with the items presented during study. Additionally, participants rated their memory for the item according to the following 4 levels: (1) "The item is new to me," (2) "The item was presented yesterday, but I have no sense of the value provided as feedback," (3) "The item was presented yesterday, and I have some sense of the correct value," or (4) "The item was presented yesterday, and I have a fairly accurate recollection of the value."

Choice 1 indicates no recognition or recollection. This is equivalent to labeling the item as "new," and it is the correct response for items from the new block. Choices 2-4 as a group indicate that the item is "old," but with varying levels of familiarity and/or recall. These are correct responses for the E, EI and E_I blocks (although choices 3 and 4 entail a belief that the participant actually received feedback at study, and so might also be considered incorrect for the E block). Choices 2 and 3 indicate perceived recognition, but at least a partial failure in recall. Choice 4 indicates a subjective sense of fairly complete recall.

Explicit recall is being used here in a somewhat different way than in most learning and memory studies. Indeed, these memory ratings can be viewed as a form of metacognition regarding the estimation process.

3.2.4 Analysis

We modeled improvement as a binomial outcome (as did Munnich et al., 2005). This allows for the treatment of items that have differing distributions within a unified framework (e.g., a linear model would have difficulty modeling both percentages and values in the billions, particularly given our sample size). Items were labeled as to whether estimates improved or not. These labels were fit with a binomial generalized linear model, using the lme4 package in the R statistical environment (R Development Core Team, 2009). This treatment allows for a full multi-factorial mixed-effects analysis. Below, participants are always included as a random effect, and other factors are treated as fixed effects. Contrasts were evaluated using the multcomp package, which controls for family-wise error rate (Hothorn, Bretz,& Westfall, 2008).

Unless otherwise noted, data were pre-processed to remove ties. This was done to allow for a null hypothesis that 50% of the remaining items randomly improved and 50% randomly worsened. If we counted ties as failures to improve, then random drift would end up spuriously suggesting the lack of an effect. Removing ties allowed for tests of whether estimates improved, on average, more than they worsenedboth formally and when examining graphs. Otherwise, the removal had little effect on the results, except where explicitly noted below.

3.3 Results

The results of central importance to the questions posed in the introductory material are...

While both *surprise* and *metacognitive memory assessment* were predictive of improved estimation from the first to the second session, these measures did not interact significantly, and moreover were uncorrelated with one another.

On it's own, this result would be insufficient to make strong claims about multiple cognitive routes for learning. But, this result fits well with an ever increasing literature, from the motor literature (Clark & Ivry, 2010), citerobinson's SRT and citeshadmehr visuo-motor word-list learning interference, citekrakauer strategy rotation the memory literature citeknowlton, davachi, wagner

Cite Clark and Wagner regarding learning with pre-existing knowledge entailing lower demands on prefrontal structures, in consort with Tse...Morris about pre-existing structures lightening the load for consolidation.

Need to pull in prior NDI results about estimation and durability of improvements.

Chapter 4

Experimental plan

4.1 Specific hypotheses

In the background section, I laid out a number of more general questions. In the light of our findings so far, I propose the following specific hypotheses:

1. Differences between NDI and mechanistic interventions on one hand, ethical, "results-based" and emotional appeals on the other:

   (a) Changes in beliefs and attitudes will be more durable following NDI-style or mechanistic interventions, as compared to more emotional or ethical appeals.

   (b) Learning from NDI-style interventions will tend to have more access to conscious memory, with greater accuracy of meta-cognitive appraisal, as well as

   These tests are straightforward, and can be assessed via immediate post-intervention and subsequent followup surveys. We will look to identify improvements in ability to cogently argue for e.g., climate change (or perhaps cogently against a better constructed representation of the pro-climate change side), as well as attitudes and behaviors. A shift to on-line surveys will allow for much larger population sizes, with the introduction of several examples of each style of intervention (to reduce the likelihood that results are due to a specific quirk of one intervention).

2. Attitudinal relationships (*a la* RTMD)

   (a) Reformulating climate change as a well-supported scientific domain will increase the correlation (i.e., coherence) between evolution acceptance and

   (b) I think we already have that one paper where decreasing individual's consideration of a deity increases their acceptance of evolution. This may also be the case with Climate Change.

   I think there's great potential here for modifying people's affect as it pertains to nationalism (and potentially consumerism).

Chapter 5

Materials

5.1 Expansion of Subject Population

5.2 Direct Observation of Emotional Response

5.3 Comparison of Factual Narrative, Collections of Facts and Emotional Narratives

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