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Designing an Intervention to Promote Critical Thinking About Statistics in the General Public

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"One in five American households do not have a single member in the labor force." This was a statistic heralded by President-elect Donald Trump (Appelbaum, 2016, para. 2), in a speech during the election campaign, to illustrate the apparently huge number of unemployed Americans and, thus, to expose the perilous state of the American economy.

However, if considered critically, this is also a statistic that is incredibly misleading.

Trump may be correct that fewer Americans, as a percentage of the total population, are engaged in traditional employment today compared to previous decades. However, the statistic above is not proof that more Americans are unemployed and, indeed, is more indicative of the fact that 20% of American households are headed by retirees (Jacobson, 2016). In this statistic, Trump is tacitly classifying retirees, 16-to-17-year-olds, and stay-at-home parents as being within the ranks of the unemployed. Although this classification may be technically accurate, it misleads the public about the general state of the economy.

The recent election campaign was characterized and arguably won on the basis of such bald misinformation and the mischaracterization of seemingly authoritative and objective statistics, figures, and facts. In a year dominated by the twin phenomena of fake news (Holan, 2016) and post-truth politics (Wang, 2016), it is more vital than ever to foster the general public's critical thinking about the numbers and statistics used—and abused—by business leaders, advocates, and policymakers. In this paper, I will describe an intervention designed to foster such critical thinking, and to enable the public to better distinguish between misleading and representative statistics. I will describe the development of this intervention, informed by our understanding of how people reason about statistics and numbers within the context of topics in the public domain, as well as techniques to foster critical thinking in the classroom.

The Impact of Statistics

A prevailing view in the realm of social psychology has been that of *cultural cognition*—the idea that people form risk perceptions and thus make decisions and form worldviews that cohere strongly with their cultural and political values (Kahan, Jenkins-Smith, & Braman, 2011). This theory is used to explain why certain groups do not believe in climate change or the effectiveness of vaccines, despite overwhelming scientific evidence to the contrary. This is because groups have a tendency to view empirical evidence in a biased manner, confirming evidence that fits with their beliefs at face value, while holding disconfirming evidence to higher critical standards (Lord, Ross

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& Lepper, 1979). People are thus unswayed by facts that do not fit within their existing views, discarding information that is contrary to their closely held beliefs. However, cultural cognition theory has been repeatedly discounted by experiments carried out by The Reasoning Group at University of California Berkeley, which has empirically demonstrated the catalyzing effect of even a single, critical statistic in changing a citizen's view on a social issue or policy, regardless of political or group identification (Ranney, Munnich, & Lamprey, 2016).

The power of germane numbers can be illustrated by a study carried out by Ranney, Cheng, Nelson, and Garcia de Osuna in 2001. In this study, the researchers asked U.S.-based participants to estimate the current legal immigration rate and state their preference for what they thought this rate should ideally be. The median estimate was a rate of 10%, with the median initial preference to keep the status quo (i.e., a rate of 10%). The participants were then shown the actual legal immigration rate, which was 0.3%. After receiving this feedback, the median participant switched from their status-quo policy to wanting immigration to become thrice its current rate (i.e., 1%)—a belief revision and change in policy preference prompted by one single, salient number.

It is a general belief that one's views on topics such as immigration, global warming, or nationalism are based on a series of connected ideas that include personal experiences, media information, religious opinion, and more general epistemic and experiential understandings of the topic. However, when exposed to a particularly surprising or shocking number, these understandings are challenged, inducing a cognitive conflict between previous beliefs and the new information. People usually resolve this conflict by revising or reorganizing their previous beliefs to incorporate these new, striking pieces of information via the Piagetian (1964) process of accommodation or the mechanism of conceptual change (Chi, 2008), causing a shift in one's views to a qualitatively different view of the issue than that previously held. Such a process is characterized in Ranney and Thagard's (1988) Theory of Explanatory Coherence, which characterizes how people change their beliefs in ways driven by considerations of explanatory coherence and how belief networks are modified to maintain coherence with new information. According to the Theory of Explanatory Coherence's Data Priority Principle, evidence that is critical, germane, repeatable, and credible carries maximal weight in our belief systems, indicating that numerical information can carry notable weight with respect to leading to accommodative belief revision (Ranney & Schank, 1998).

Such conceptual restructuring upon receiving new or surprising information is not necessarily a bad thing; indeed, it is what we characterize as learning, or what the Gestalt psychologist Wertheimer (1959) would term *productive thinking*—the process by which becoming aware of a gap or knowledge void prompts a person to increase global coherence amongst their beliefs. Perception of this knowledge void is attenuated by surprise—and thus, it is the most surprising numbers and stories that have the most potential to spawn considerable cognitive change and belief revision (Ranney & Clark, 2016). It has also been found that the more surprised people are by numbers, the less knowledgeable they report feeling about an issue, and thus, the more open they are to changing their beliefs in line with the number—a phenomenon known in the media as *the establishing effect* (Yarnall & Ranney, 2017). This is illustrated by the fact that participants who were surprised by the immigration rate in the 2001 experiment, for instance, were four times more likely to significantly change their positions on the issue than those participants who were less surprised (Ranney et al., 2001).

Defining Critical Thinking

Numerical data, however, is most helpful when the data are reliable and accurate. Importantly, media sources and elected officials can risk misinforming people with incorrect and/or misleading and unrepresentative data that are often not critically vetted by the press or the public itself. How, then, can we give people the tools to resist being misled by such deceptive statistics and figures? One possible avenue would be to encourage the development of critical thinking in the general populace. *Critical thinking* is often defined as a Gestalt-like process of learning through becoming aware of one's own ignorance. Ranney and Schank (1998) extended this definition by hypothesizing that critical thinking means thinking more like a scientist and forming opinions using "scientific" as opposed to "plain old" reasoning (p. 1). With this kind of thinking, the reasoner employs more formal tools, such as deduction and alternative-hypothesis generation, and is more likely to vigilantly search for disconfirmation and be more selective about which new information to accommodate. Such scientific reasoning is considered to be more empirical, objective, rigorous, and accountable—and less emotional—than what is commonly understood by social reasoning.

An important component of such critical thinking and, some would argue, a distinguishing feature of it, is an awareness of the thought process itself—for instance, an awareness of how new information may fit with prior beliefs, and a conscious assessment of whether a statistic or figure offers strong evidence for what it is claiming. Such regulatory thought processes assessing the act of learning as it takes place are commonly defined in the education literature as *metacognition*—a necessary prerequisite for developing expertise in a subject (Sternberg, 1998). Metacognition has been shown to be fostered through several classroom techniques, such as encouraging students to brainstorm and generate their own responses, and to learn actively rather than simply being shown the right answer (Schoenfeld, 1987). Argumentation in the classroom is another way metacognition can be fostered, and it has been shown that students who articulate, interrelate, and revise their own arguments are more resistant to the biasing influences of extraneous information (Kuhn, Zillmer, Crowell, & Zavala, 2013).

Developing the Intervention

My aim was to develop a short, text-based intervention that would promote critical thinking about statistics, drawing people's attention to common aspects of uninformative and misleading statistics, and thus enabling them to more easily differentiate between misleading and representative statistics. To begin, we drew on a numeracy curriculum, developed and piloted for journalism students at University of California Berkeley by Michael Ranney and colleagues in 2008. This curriculum was created in response to the fact that journalists have a reported tendency to avoid backing up stories with relevant quantitative information. In one exercise in the curriculum's Numbers, News and Evidence module, a fictional colleague called Pat offers a series of alleged statistics, one third of which are correct with the remaining two thirds being higher or lower than the true values. Journalism students exposed to the curriculum viewed Pat's statistics increasingly critically the more that they were exposed to them, indicating that exposure to a mixed set of statistics in itself promotes increased skepticism with respect to quantitative information.

We extended this exercise for our training, providing a number of statistics that we asked participants to rate on a -4 to +4 scale, depending on how misleading, revealing, and/or pointless they found them. In some of the example statistics, we had a blank where the numerical portion of the statistic was, for example, __% as opposed to 42%, in order to ascertain whether this would have any effect on how the participants thought about and/or rated the statistic. In this, we were drawing on previous work of The Reasoning Group, which has suggested that the practice of Numerically-Driven Inferencing (i.e., being asked to estimate unknown quantities related to important policy issues before receiving the true values as feedback) fosters critical thinking (Munnich, Ranney, & Appel, 2004). Not seeing or being told the number directly means that participants have to go through the step of estimating what this quantity would be, activating a network of facts, set relationships, and causal beliefs about an issue. Such an activation mirrors the eliciting of prior knowledge in a classroom, where students are often encouraged to voice the misconceptions or prior beliefs about a subject that they bring with them (Hewson & Hewson, 1983). The justification behind this is that if students do not perceive a conflict between their prior knowledge and new information, they are more likely to simply assimilate the new information to form a flawed and inconsistent mental model. However, when the learner perceives a conflict between new information and their prior beliefs, then the process of belief revision occurs, leading to conceptual change and productive learning. It is this process of active accommodation that we wished to activate in participants because it is through this process that people are most likely to critically assess the evidential quality of the new information. Another aspect of the training was providing the space for participants to self-explain or think aloud their ratings of the statistics. This was informed by research carried out by Chi, De Leeuw, Chiu, and LaVancher (1994) who showed that self-explaining leads to a deeper understanding of the material covered and to the improved acquisition of problem-solving skills.

Alongside example statistics to rate, we also gave participants textual instruction that drew explicit attention to potentially misleading and/or non-representative aspects of statistics, such as quantities lacking temporal or spatial breadth and quantities lacking measurement precision. We also encouraged participants to examine causality and the source of statistics—thus, encouraging the activation of mechanistic as well as numerical reasoning that we hope will lead people to more readily discount misleading or misrepresentative information.

The intervention was specifically designed to focus on building metacognitive and quantitative critical-reasoning skills—an aspect missing from the majority of college statistics curricula. Indeed, a study by Sorto (2006) found that only 1.3–2.6% of statistics curricula dealt explicitly with statistical reasoning (i.e., how to form inferences and generalize from statistics), with the majority having an overemphasis on the procedural, overtly mathematical end of statistics. Specifically, we wanted to steer away from mathematical training in this intervention, with the knowledge that for a large portion of the population, any form of explicit mathematical and/or scientific training is likely to generate high levels of fear and anxiety and have a knock-on effect on motivation, persistence, and even reasoning ability (Birenbaum & Eylath, 1994).

Conclusion

The use of facts and figures in contemporary politics is a double-edged sword: On one hand, such numbers and statistics ground statements in a much-needed objective reality. However, on the other hand, the seeming authority of such numbers and statistics can be easily exploited. Indeed, the repeated references to shocking and misleading numerical information by journalists and policymakers has arguably led to an increased distrust of experts, facts, and data itself by the American public, and has thus heralded in an era of post-truth politics—a politics in which debates are conducted via highly emotive appeals rather than based on verifiable facts. All this has led to a reality where the truth is indistinguishable from fiction; a recent Stanford University survey showed that more than 80% of supposedly digital-savvy students could not tell the difference between a real news story and a fake piece of sponsored content (Donald, 2016).

The reality of having a president unconstrained by facts, together with a media polluted with fake and unverifiable clickbait, poses an urgent challenge for educators, particularly those of math and science. Our challenge is to equip students and the general population with the tools to question and refute outright lies while appreciating the value of facts, statistics, and verifiable truths in public debate. Testing the effectiveness of the intervention described above will shed light on the cognitive mechanisms that are at play when people engage with facts and statistics, and is thus a step in the right direction with respect to empowering future citizens to behave intelligently in an increasingly complex and uncertain future.

Author Biography

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